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PROCEEDINGS

OF

THE AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE.

SIXTEENTH MEETING,

HELD AT BURLINGTON, VERMONT,

AUGUST, 1867.

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1868.

EDITED BY

JOSEPH LOVERING,

Permanent Secretary

1860
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TABLE OF CONTENTS.

PAGE

Officers of the Association, ... vii
Committees, ... ix
Officers of the next Meeting, ... x
Meetings of the Association, ... xi
Constitution of the Association, ... xiii
Resolutions and Enactments of a Permanent and Prospective Character, xxi
List of Members, ... xxiii
Members elected at the Burlington Meeting, ... xxxxi

Address of the President, J. S. Newberry, ... 1

COMMUNICATIONS.

A. MATHEMATICS, PHYSICS, AND CHEMISTRY.

1. MATHEMATICS AND ASTRONOMY.

1. Communication of Vibrations. By Benjamin Peirce, . . . 17
2. On the Determination of Geographical Latitude from Observations in the Prime Vertical. By William A. Rogers, . . . 19

3. Remarks on Personal Equation in Transit Observations. By G. W. Hough, ... 22
4. Observations of Venus near Inferior Conjunction. By C. S. Lyman, ... 23

II. ACOUSTICS.

1. On the Optical Method of Studying Sound. By Joseph Lovering, ... 25
2. On a Method of Measuring Musical Intervals upon a Spiral Projection. By Samuel D. Tillman, ... 27
3. On a New Form of Wave Apparatus. By C. S. Lyman, . . 33

III. PHYSICS AND CHEMISTRY.

1. Tellurium, a Metal. By L. Bradley, ... 37
2. Preliminary Notice of Experiments on Snow at Temperatures below 32° Fahrenheit. By Edward Hungerford, . . 39
3. Chemical Diagrams and Derivative Symbols, illustrating the Prominent Characteristics of Chemical Elements. By Samuel D. Tillman, ... 39
4. A New Chemical Nomenclature. By Samuel D. Tillman, . 50

IV. PHYSICS OF THE GLOBE.

1. On the Periodicity of the Aurora Borealis. By Joseph Lovering, ... 82
2. Remarks on Meteorological Results deduced from the New Method of Registration. By G. W. Hough, ... 89

B. NATURAL HISTORY.

I. GEOLOGY AND MINERALOGY.

1. Depression of the Ocean during the Ice Period. By Charles Whittlesey, ... 92
2. Abstract of Remarks upon the Occurrence of Iron in Masses. By Charles Whittlesey, ... 97

3. Considerations relating to the Climate of the Glacial Epoch in North America. By EDWARD HUNGERFORD, . . . 108
4. Ripton Sea Beaches. By EDWARD HUNGERFORD, . . 112
5. On the Lower Silurian Hematite Beds of America. By B. S. LYMAN, ... 114
6. On Recent Geological Discoveries in the Acadian Provinces of British America. By J. W. DAWSON, ... 117
7. The Winooski Marble of Colchester, Vt. By C. H. HITCHCOCK, . 119
8. The Geology of Vermont. By C. H. HITCHCOCK, . . 120
9. Explanation of a Geological Map of Maine. By C. H. HITCHCOCK, ... 123
10. The Distortion and Metamorphosis of Pebbles in Conglomerates. By C. H. HITCHCOCK, ... 124
11. Tracts of Ancient Glaciers in the White Mountains of New Hampshire, with a few Remarks upon the Geological Structure of some Portions of that Group. By GEORGE L. VOSE, . . 127
12. The Red Sandstone of Vermont and its Relations. By JOHN S. PERRY, ... 128
13. On the Origin of the So-called Lignilites or Epsomites. By O. C. MARSH, ... 135

II. PALÆONTOLOGY.

1. On some Fossil Reptiles and Fishes, from the Carboniferous Strata of Ohio, Kentucky, and Illinois. By J. S. NEWBERRY, . . 144
2. On some Remarkable Fossil Fishes, discovered by Rev. H. HERZER, in the Black Shale (Devonian) at Delaware, Ohio. By J. S. NEWBERRY, ... 146
3. On the Zoölogical Affinities of the Tabulate Corals. By A. E. VERRILL, ... 148

III. ZOÖLOGY.

1. Considerations drawn from the Study of the Orthoptera of North America. By SAMUEL H. SCUDDER, ... 151
2. The Embryology of Libellula (Diplax) with Notes on the Morphology of Insects and the Classification of the Neuroptera. By A. S. PACKARD, JR., ... 153
3. The Insect Fauna of the Summit of Mount Washington, as compared with that of Labrador. By A. S. PACKARD, JR., . 154

Papers Presented, but only Published by Title, . . 159

EXECUTIVE PROCEEDINGS.

History of the Meeting, ... 162
Opening Prayer, by Rev. M. H. Buckham, ... 162
Welcome, by Hon. Mayor Torrey E. Wales, ... 163
Reply, by J. S. Newberry, President, ... 164
Next Meeting, ... 165
Officers Elected, ... 165
Festivities, ... 166
Resolutions Adopted, ... 167
Votes of Thanks, ... 170
Report of Joseph Lovering, Permanent Secretary, . . . 171
Cash Account of the Permanent Secretary, ... 172
Report of the Auditors, ... 173
Stock Account of the Permanent Secretary, ... 174
Volumes distributed to European Institutions, . . 175

Index, ... 177

OFFICERS OF THE ASSOCIATION

AT THE

BURLINGTON MEETING.

J. S. Newberry, *President.*
Wolcott Gibbs, *Vice-President.*
Joseph Lovering, *Permanent Secretary.*
C. S. Lyman, *General Secretary.*
Dr. A. L. Elwyn, *Treasurer.*

Standing Committee.

EX-OFFICIO.

J. S. Newberry,
Wolcott Gibbs,
Joseph Lovering,
C. S. Lyman,

F. A. P. Barnard,
A. A. Gould,*
Elias Loomis,
A. L. Elwyn.

AS CHAIRMEN OF THE SECTIONAL COMMITTEES.

J. W. Dawson,

Charles Whittlesey.

FROM THE ASSOCIATION AT LARGE.

E. N. Horsford,
J. B. Angell,
Alexis Caswell,

B. A. Gould,
J. H. Coffin,
G. W. Hough.

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* Died before the meeting.

Local Committee.

TORREY E. WALES, *Chairman.*
EDWARD HUNGERFORD, *Secretary.*
JAMES W. HICKOCK, *Treasurer.*

ALBERT L. CATLIN,
G. G. BENEDICT,
M. H. BUCKHAM,
EDWARD W. PECK,
D. D. HOWARD,
HENRY LOOMIS,
GEORGE H. BIGELOW,
LAWRENCE BARNES,
GEORGE F. EDMANDS,
D. C. LINSLEY.

Committee of Arrangements.

EDWARD W. PECK, | ALBERT L. CATLIN,
JAMES W. HICKOK.

SPECIAL COMMITTEES.

A. Committees continued from former Meetings.

1. *Committee to Report in Relation to Uniform Standards in Weights, Measures, and Coinage.*

John Torrey,
H. A. Newton,
Joseph Henry,
Wolcott Gibbs,
Benjamin Peirce,
John LeConte,
W. B. Rogers,
J. E. Hilgard,
John F. Frazer,
J. H. Gibbon,
B. A. Gould,
J. L Smith.

B. New Committees.

1. *Committee to Audit the Accounts of the Permanent Secretary and the Treasurer.*

B. A. Gould,
C. S. Lyman.

2. *Committee with whom the Permanent Secretary may advise in regard to the publication of the Burlington Proceedings.*

B. A. Gould,
W. B. Rogers.

3. *Committee to act with the Standing Committee in nomination of Officers for the Chicago Meeting.*

Section A.	Section B.
A. P. Rockwell,	A. H. Worthen,
E. L. Youmans,	John Torrey,
O. N. Rood,	J. W. Dawson,
Charles F. Chandler.	L. H. Morgan.

OFFICERS OF THE CHICAGO MEETING.

B. A. Gould, *President.*
Charles Whittlesey, *Vice-President.*
Joseph Lovering, *Permanent Secretary.*
A. P. Rockwell, *General Secretary.*
A. L Elwyn, *Treasurer.*

Standing Committee.

B. A. Gould,
Charles Whittlesey,
Joseph Lovering,
A. P. Rockwell,
J. S. Newberry,
Wolcott Gibbs,
C. S. Lyman,
A. L. Elwyn,

Local Committee.

William Stimpson, *Secretary.*

Edmund Andrews,
John F. Beaty,
J. V. Z. Blaney,
E. W. Blatchford,
William Bross,
E. S. Chesbrough,
Edward Daniels,
W. E. Doggett,
J. W. Foster,
Walter Hay,
E. B. McCogg,
John H. Rauch,
T. H. Safford,
J. Young Scammon,
E. H. Sheldon,
George C. Walker,
John M. Woodworth.

MEETINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Meeting.	Date.	Place.	President.	Vice-President.	General Secretary.	Permanent Secretary.	Treasurer.
1st,	Sept. 20, 1848,	Philadelphia, Pa.	W. C. Redfield.		Walter R. Johnson,		Jeffries Wyman.
2d,	Aug. 14, 1849,	Cambridge, Mass.,	Joseph Henry,		E. N. Horsford,		A. L. Elwyn.
3d,	March, 12, 1850,	Charleston, S. C.,	A. D. Bache,*		L. R. Gibbes,*		St. J. Ravenel.*
4th,	Aug. 19, 1850,	New Haven, Ct.,	A. D. Bache,		E. C. Herrick,		A. L. Elwyn.
5th,	May 5, 1851,	Cincinnati, Ohio,	A. D. Bache,		W. B. Rogers,	S. F. Baird,	A. L. Elwyn.
6th,	Aug. 19, 1851,	Albany, N. Y.,	Louis Agassiz,		W. B. Rogers,	S. F. Baird,	A. L. Elwyn.
7th,	July 28, 1853,	Cleveland, Ohio,	Benj. Peirce,		J. D. Dana,	S. F. Baird,	A. L. Elwyn.
8th,	April 26, 1854,	Washington, D. C.,	J. D. Dana,		J. Lawrence Smith,	Joseph Lovering,	J. L. LeConte.*

* In the absence of the regular officer.

MEETINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Meeting.	Date.	Place.	President.	Vice-President.	General Secretary,	Permanent Secretary.	Treasurer.
9th,	Aug. 15, 1855,	Providence, R. I.,	John Torrey,		Wolcott Gibbs,	Joseph Lovering,	A. L. Elwyn.
10th,	Aug. 20, 1856,	Albany, N. Y.,	James Hall,		B. A. Gould,	Joseph Lovering,	A. L. Elwyn.
11th,	Aug. 12, 1857,	Montreal, C. E.,	J. W. Bailey,	Alexis Caswell,	John LeConte,	Joseph Lovering,	A. L. Elwyn.
12th,	April 28, 1858,	Baltimore, Md.,	Alexis Caswell,*	John E. Holbrook,	W. M. Gillespie,	Joseph Lovering,	A. L. Elwyn.
13th,	Aug. 3, 1859,	Springfield, Mass.,	S. Alexander,	Edward Hitchcock,	William Chauvenet,	Joseph Lovering,	A. L. Elwyn.
14th,	Aug. 1, 1860,	Newport, R. I.,	Isaac Lea,	B. A. Gould,	Joseph LeConte,	Joseph Lovering,	A. L. Elwyn.
15th,	Aug. 15, 1867,	Buffalo, N. Y.,	F. A. B. Barnard,	A. A. Gould,	Elias Loomis,	Joseph Lovering,	A. L. Elwyn.
16th,	Aug. 21, 1868,	Burlington, Vt.,	J. S. Newberry,	Wolcott Gibbs,	C. S. Lyman,	Joseph Lovering,	A. L. Elwyn.

* In the absence of the regular officer.

CONSTITUTION OF THE ASSOCIATION.*

OBJECTS.

The Association shall be called "The American Association for the Advancement of Science." The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of the United States, to give a stronger and more general impulse, and a more systematic direction, to scientific research in our country, and to procure for the labors of scientific men increased facilities and a wider usefulness.

MEMBERS.

Rule 1. Members of scientific societies, or learned bodies, having in view any of the objects of this Association, and publishing transactions, shall be considered members on subscribing these rules.

Rule 2. Collegiate professors, also civil engineers and architects, who have been employed in the construction or superintendence of public works, may become members on subscribing these rules.

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* Adopted August 25, 1856, and ordered to go into effect at the opening of the Montreal Meeting. Amended at Burlington, August, 1867

Rule 3. Persons not embraced in the above provisions may become members of the Association upon recommendation in writing by two members, nomination by the Standing Committee, and election by a majority of the members present.

OFFICERS.

Rule 4. The officers of the Association shall be a President, Vice-President, General Secretary, Permanent Secretary, and Treasurer. The President, Vice-President, General Secretary, and Treasurer shall be elected at each meeting for the following one; — the three first-named officers not to be re-eligible for the next two meetings, and the Treasurer to be re-eligible as long as the Association may desire. The Permanent Secretary shall be elected at each second meeting, and also be re-eligible as long as the Association may desire.

MEETINGS.

Rule 5. The Association shall meet, at such intervals as it may determine, for one week, or longer, — the time and place of each meeting being determined by a vote of the Association at the previous meeting; and the arrangements for it shall be intrusted to the officers and the Local Committee.

STANDING COMMITTEE.

Rule 6. There shall be a Standing Committee, to consist of the President, Vice-President, Secretaries, and Treasurer of the Association, the officers of the preceding year, the permanent Chairman of the Sectional Committees, after these shall have been organized, and six members present from the Association at large, who shall have attended any of the previous meetings, to be elected upon open nomination by ballot on the first assembling of the Association. A majority of the whole number of votes cast to elect. The General Secretary shall be Secretary of the Standing Committee.

The duties of the Standing Committee shall be, —

1. To assign papers to the respective sections.

2. To arrange the scientific business of the general meetings, to suggest topics, and arrange the programmes for the evening meetings.

3. To suggest to the Association the place and time of the next meeting.

4. To examine, and, if necessary, to exclude papers.

5. To suggest to the Association subjects for scientific reports and researches.

6. To appoint the Local Committee.

7. To have the general direction of publications.

8. To manage any other general business of the Association during the session, and during the interval between it and the next meeting.

9. In conjunction with four from each Section, to be elected by the Sections for the purpose, to make nominations of officers of the Association for the following meeting.

10. To nominate persons for admission to membership.

11. Before adjourning, to decide which papers, discussions, or other proceedings shall be published.

SECTIONS.

Rule 7. The Association shall be divided into two Sections, and as many sub-Sections as may be necessary for the scientific business, the manner of division to be determined by the Standing Committee of the Association. The two Sections may meet as one.

SECTIONAL OFFICERS AND COMMITTEES.

Rule 8. On the first assembling of the Section, the members shall elect upon open nomination a permanent Chairman and Secretary, also three other members, to constitute, with these officers, a Sectional Committee.

The Section shall appoint, from day to day, a Chairman to preside over its meetings.

Rule 9. It shall be the duty of the Sectional Committee of each Section to arrange and direct the proceedings in their Section; to ascertain what communications are offered; to assign the order in which these communications shall appear, and the amount of time which each shall occupy.

The Sectional Committees may likewise recommend subjects for systematic investigation by members willing to undertake the researches, and to present their results at the next meeting.

The Sectional Committee may likewise recommend reports on particular topics and departments of science, to be drawn up as occasion permits, by competent persons, and presented at subsequent meetings.

REPORTS OF PROCEEDINGS.

Rule 10. Whenever practicable, the proceedings shall be reported by professional reporters, or stenographers, whose reports are to be revised by the Secretaries before they appear in print.

PAPERS AND COMMUNICATIONS.

Rule 11. No paper shall be placed in the programme, unless admitted by the Sectional Committee; nor shall any be read, unless an abstract of it has been previously presented to the Secretary of the Section, who shall furnish to the Chairman the titles of papers, of which abstracts have been received.

Rule 12. The author of any paper or communication shall be at liberty to retain his right of property therein, provided he declares such to be his wish before presenting it to the Association.

RULE 13. Copies of all communications, made either to the General Association or to the Sections, must be furnished by the authors; otherwise only the titles, or abstracts, shall appear in the published proceedings.

RULE 14. All papers, either at the general or in the sectional meetings, shall be read, as far as practicable, in the order in which they are entered upon the books of the Association; except that those which may be entered by a member of the Standing Committee of the Association shall be liable to postponement by the proper Sectional Committee.

RULE 15. If any communication be not ready at the assigned time, it shall be dropped to the bottom of the list, and shall not be entitled to take precedence of any subsequent communication.

RULE 16. No exchanges shall be made between members without authority of the respective Sectional Committees.

GENERAL AND EVENING MEETINGS.

RULE 17. The Standing Committee shall appoint any general meeting which the objects and interests of the Association may call for, and the evenings shall, as a rule, be reserved for general meetings of the Association.

These general meetings may, when convened for that purpose, give their attention to any topics of science which would otherwise come before the Sections.

It shall be a part of the business of these general meetings to receive the Address of the President of the last meeting; to hear such reports on scientific subjects as, from their general importance and interests, the Standing Committee shall select; also to receive from the Chairman of the Sections abstracts of the proceedings of their respective Sections; and to listen to communications and lectures explanatory of new and important discoveries and researches in science, and new inventions and processes in the arts.

ORDER OF PROCEEDINGS IN ORGANIZING A MEETING.

RULE 18. The Association shall be called to order by the President of the preceding meeting; and this officer having resigned the chair to the President elect, the General Secretary shall then report the number of papers relating to each department which have been registered, and the Association consider the most eligible distribution into Sections, when it shall proceed to the election of the additional members of the Standing Committee in the manner before described; the meeting shall then adjourn, and the Standing Committee, having divided the Association into sections as directed, shall allot to each its place of meeting for the Session. The Sections shall then organize by electing their officers and their representatives in the Nominating Committee, and shall proceed to business.

PERMANENT SECRETARY.

RULE 19. It shall be the duty of the Permanent Secretary to notify members who are in arrears, to provide the necessary stationery and suitable books for the list of members and titles of papers, minutes of the general and sectional meetings, and for other purposes indicated in the rules, and to execute such other duties as may be directed by the Standing Committee or by the Association.

The Permanent Secretary shall make a report annually to the Standing Committee, at its first meeting, to be laid before the Association, of the business of which he has had charge since its last meeting.

All members are particularly desired to forward to the Permanent Secretary, so as to be received before the day appointed for the Association to convene, complete titles of all the papers which they expect to present during its meeting, with an estimate of the time required for reading each, and such abstracts of their contents as may give a general idea of their nature.

Whenever the Permanent Secretary notices any error of fact or unnecessary repetition, or any other important defect in the papers communicated for publication in the proceedings of the Association, he is authorized to commit the same to the author, or to the proper sub-committee of the Standing Committee for correction.

LOCAL COMMITTEE.

Rule 20. The Local Committee shall be appointed from among members residing at, or near, the place of meeting for the ensuing year; and it shall be the duty of the Local Committee, assisted by the officers, to make arrangements and the necessary announcements for the meeting.

The Secretary of the Local Committee shall issue a circular in regard to the time and place of meetings, and other particulars, at least one month before each meeting.

SUBSCRIPTIONS.

Rule 21. The amount of the subscription, at each meeting of each member of the Association shall be two dollars, and one dollar in addition shall entitle him to a copy of the proceedings of the annual meeting. These subscriptions shall be received by the Permanent Secretary, who shall pay them over, after the meeting, to the Treasurer.

The admission fee of new members shall be five dollars, in addition to the annual subscription: and no person shall be considered a member of the Association until this admission fee and the subscription for the meeting at which he is elected have been paid.

Rule 22. The names of all persons two years in arrears for annual dues shall be erased from the list of members; provided that two notices of indebtedness, at an interval of at least three months, shall have been previously given.

ACCOUNTS.

RULE 23. The accounts of the Association shall be audited, annually, by auditors appointed at each meeting.

ALTERATIONS OF THE CONSTITUTION

RULE 24. No article of this constitution shall be altered, or amended, or set aside, without the concurrence of three fourths of the members present, and unless notice of the proposed change shall have been given at the preceding annual meeting.

NOTE.

A proposition to rescind Rules 1 and 2 and to alter the phraseology of Rule 3, so as to conform to the proposed amendments, was made at the Burlington meeting, and will come up for final action at the meeting in Chicago.

RESOLUTIONS

OF A

PERMANENT AND PROSPECTIVE CHARACTER,

ADOPTED AUGUST 19, 1857.

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1. No appointment may be made in behalf of the Association, and no invitation given or accepted, except by vote of the Association or its Standing Committee.

2. The General Secretary shall transmit to the Permanent Secretary for the files, within two weeks after the adjournment of every meeting, a record of the proceedings of the Association and the votes of the Standing Committee. He shall also, daily, during the meetings, provide the Chairman of the two Sectional Committees with lists of the papers assigned to their Sections by the Standing Committee.

3. All printing for the Association shall be superintended by the Permanent Secretary, who is authorized to employ a clerk for that especial purpose.

4. The Permanent Secretary is authorized to put the proceedings of the meetings to press one month after the adjournment of the Association. Papers which have not been received at that time may be published only by title. No notice of articles not approved shall be taken in the published proceedings.

5. The Permanent Chairmen of the Sections are to be considered their organs of communication with the Standing Committee.

6. It shall be the duty of the Secretaries of the two Sections to receive copies of the papers read in their Sections, all sub-sections included, and to furnish them to the Permanent Secretary at the close of the meeting.

7. The Sectional Committees shall meet not later than 9 A. M. daily, during the meetings of the Association, to arrange the programmes of their respective sections, including all sub-sections, for the following day. No paper shall be placed upon these programmes which shall not have been assigned to the Section by the Standing Committee. The programmes are to be furnished to the Permanent Secretary not later than 11 A. M.

8. During the meetings of the Association, the Standing Committee shall meet daily, Sundays excepted, at 9 A. M., and the Sections be called to order at 10 A. M., unless otherwise ordered. The Standing Committee shall also meet on the evening preceding the first assembling of the Association at each annual meeting, to arrange for the business of the first day; and on this occasion three shall form a quorum.

9. Associate members may be admitted for one, two, or three years as they shall choose at the time of admission, — to be elected in the same way as permanent members, and to pay the same dues. They shall have all the social and scientific privileges of members, without taking part in the business.

10. No member may take part in the organization and business arrangement of both the Sections.

MEMBERS

OF THE

AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE.

NOTE. — Names of deceased members are marked with an asterisk [*]. The figure at the end of each name refers to the meeting at which the election took place.

A.

Abbe, Cleveland, Washington, District of Columbia (16).
*Adams, C. B., Amherst, Massachusetts (1).
Adelberg, Justus, New York, New York (15).
Aiken, W. E. A., Baltimore, Maryland (12).
Ainsworth, J. G., Barry, Massachusetts (14).
Albert, Augustus J., Baltimore, Maryland (12).
Alexander, Stephen, Princeton, New Jersey (1).
Allen, E. A. H., New Bedford, Massachusetts (6).
*Ames, M. P., Springfield, Massachusetts (1).
Andrews, E. B., Marietta, Ohio (7).
Angell, James B., Burlington, Vermont (16).
*Appleton, Nathan, Boston, Massachusetts (1).

B.

*Bache, Alexander D., Washington, District of Columbia (1).
Bacon, John, Jr., Boston, Massachusetts (1).
*Bailey, J. W., West Point, New York (1).
Baird, S. F., Washington, District of Columbia (1).
Bardwell, F. W., Jacksonville, Florida (13).
Barlow, Thomas, Canastota, New York (7).
Barnard, F. A. P., New York, New York (7).
Barnard, Henry, Madison, Wisconsin (12).
Barnard, J. G., Washington, District of Columbia (14).
Barnes, James, Springfield, Massachusetts (5).
Barratt, Joseph, Middletown, Connecticut (13).
Basnett, Thomas, Ottawa, Illinois (8).
Batchelder, J. M., Cambridge, Massachusetts (8).
Beadle, E. R., Hartford, Connecticut (10).
*Beck, C. F., Philadelphia, Pennsylvania (1).
*Beck, Lewis C., New Brunswick, New Jersey (1).
*Beck, T. Romeyn, Albany, New York (1).
Bell, Samuel N., Manchester, New Hampshire (7).
Benedict, G. W., Burlington, Vermont (16).
Bigelow, George H., Burlington, Vermont (16).
*Binney, Amos, Boston, Massachusetts (1).
*Binney, John, Boston, Massachusetts (3).
Bird, William A., Buffalo, New York (15).
Blake, Eli W., Burlington, Vermont (15).
Blake, Eli W., New Haven, Connecticut (1).
*Blanding, William, Rhode Island (1).
*Bomford, George, Washington, District of Columbia (1).
Bouve, Thomas T. Boston, Massachusetts (1).
Bowditch, Henry J., Boston, Massachusetts (2).
Bradford, Isaac, Jacksonville, Florida (14).
Bradish, Alvah, Fredonia, New York (15).
Bradley, L., Jersey City, New Jersey (15).
Brayley, James, Buffalo, New York (15).
Brevoort, J. Carson, Brooklyn, New York (1).
Briggs, A. D., Springfield, Massachusetts (13).
Bross, William, Chicago, Illinois (7).

Brown, Robert D., Jr., Cincinnati, Ohio (11).
Brush, George J., New Haven, Connecticut (11).
Buchanan, Robert, Cincinnati, Ohio (2).
Buck, C. E., New York, New York (15).
*Burnap, G. W., Baltimore, Maryland (12).
*Burnett, Waldo I., Boston, Massachusetts (1).
Butler, Thomas B., Norwalk, Connecticut (10).

C.

*Carpenter, Thornton, Camden, South Carolina (7).
*Carpenter, William M., New Orleans, Louisiana (1).
Case, Leonard, Cleveland, Ohio (15).
*Case, William, Cleveland, Ohio (6).
Cassels, J. L., Cleveland, Ohio (7).
Caswell, Alexis, Providence, Rhode Island (2).
Cattell, William C., Easton, Pennsylvania (15).
Chadbourne, P. A., Williamstown, Massachusetts (10).
Chapin, A. L., Beloit, Wisconsin (14).
*Chapman, N., Philadelphia, Pennsylvania (1).
Chase, George I., Providence, Rhode Island (1).
*Chase, S., Dartmouth New Hampshire (2).
Chauvenet, William, St. Louis, Missouri (1).
Chesbrough, E. S., Chicago, Illinois (2).
Chester, Albert H., New York, New York (15).
Chester, Albert T., Buffalo, New York (15).
Chittenden, L. E., New York, New York (14).
Churchill, Marlborough, Sing Sing, New York (13).
Clapp, Almon M., Buffalo, New York (15).
*Clapp, Asahel, New Albany, Indiana (1).
*Clark, Joseph, Cincinnati, Ohio (5).
Clark, Henry, Worcester, Massachusetts (14).
Cleaveland, C. H., Cincinnati, Ohio (9).
*Cleveland, A. B., Cambridge, Massachusetts (2).
Clinton, George W., Buffalo, New York (15).
Clum, Henry A., New York, New York (9).
Coakley, George W., New York, New York (5).
Cochran, D. H., Brooklyn, New York (15).
Coffin, C. C., Malden, Massachusetts (13).
Coffin James H., Easton, Pennsylvania (1).

Coffin, John H. C., Washington, District of Columbia (1).
*Cole, Thomas, Salem, Massachusetts (1).
*Coleman, Henry, Boston, Massachusetts (1).
Comstock, C. B., West Point, New York (14).
Conant, Marshall, Washington, District of Columbia (7).
Conkling, Frederick A., New York, New York (11).
Conway, M. D., Cincinnati, Ohio (14).
Copes, Joseph S., New Orleans, Louisiana (11).
Corning, Erastus, Albany, New York (6).
Craig, B. F. Washington, District of Columbia (15).
Cramp, J. M., Acadia College, Nova Scotia (11).
Credner, Herman, New York, New York (15).
Crosby, Alpheus, Salem, Massachusetts (10).
Cummings, Joseph, Middletown, Connecticut (13).

D.

Dalrymple, Rev. E. A., Baltimore, Maryland (11).
Dana, James, D., New Haven, Connecticut (1).
Danforth, Edward, Troy, New York (11).
Davies, Charles, Fishkill, New York (10).
Davis, James, Jr., Boston, Massachusetts (1).
Dawson, J. W., Montreal, Canada (10).
Dean, Amos, Albany, New York (6).
Dean, George W., Fall River, Massachusetts (15).
*Dearborn, George H. A. S., Roxbury, Massachusetts (1).
*Dekay, James E., New York, New York (1).
Delano, B. L., Boston, Massachusetts (16).
Delano, Joseph C., New Bedford, Massachusetts (5).
Denson, Claudius B., Pittsboro, North Carolina (12).
*Dewey, Chester, Rochester, New York (1).
Dexter, G. M., Boston, Massachusetts (11).
Dinwiddie, Robert, New York, New York (1).
Dixwell, Epes S., Cambridge, Massachusetts (1).
Dobbins, David P., Buffalo, New York (15).
Dorr, E. P., Buffalo, New York (15).
Dow, George W., Chicago, Illinois (13).
Downes John, Washington, District of Columbia (10).
Drowne, Charles, Troy, New York (6).

*Ducatel, J. T., Baltimore, Maryland (1).
Duffield, George, Detroit, Michigan (10).
*Dumont, A. H., Newport, Rhode Island (14).
*Duncan, Lucius C., New Orleans, Louisiana (10).
*Dunn, R. P., Providence, Rhode Island (14).
Dunn, T. C., Newport, Rhode Island (14).
Dyer, Elisha, Providence, Rhode Island (9).

E.

Easton, Norman, Fall River, Massachusetts (14).
Eaton, Daniel C., New Haven, Connecticut (13).
Eliot, Charles W., Boston, Massachusetts (14).
Elliott, Ezekiel B., Boston, Massachusetts (10).
Elwyn, Alfred L., Philadelphia, Pennsylvania (1).
Emerson, George B., Boston, Massachusetts (1).
Engelmann, George, St. Louis, Missouri (1).
Engstrom, A. B., Burlington, New Jersey (1).
Eustis, Henry L., Cambridge, Massachusetts (2).
Evans, Charles W., Buffalo, New York (15).
*Everett, Edward, Boston, Massachusetts (2).
Everett, J. D. Winsor, Nova Scotia (14).
Ewing, Thomas, Lancaster, Ohio (5).

F.

Fairbanks, Henry, Hanover, New Hampshire (14).
Farnham, Thomas, Buffalo, New York (15).
Ferrell, William, Nashville, Tennessee (11).
Ferris, Isaac, New York, New York (6).
Field, Roswell, Greenfield, Massachusetts (13).
Fillmore, Millard, Buffalo, New York (7).
Fisher, Mark, Trenton, New Jersey (10).
*Fitch, Alexander, Hartford, Connecticut (1).
Fitch, Edward H., Ashtabula, Ohio (11).
Fitch, O. H., Ashtabula, Ohio (7).
Forbush, E. B., Buffalo, New York (15).
Force, Peter, Washington, District of Columbia (4).
Fosgate, Blanchard, Auburn, New York (7).
Foster, J. W., Chicago, Illinois (1).
*Fox, Charles, Grosse Isle, Michigan (7).
Frothingham, Frederick, Buffalo, New York (11).

G.

*Gay, Martin, Boston, Massachusetts (1).
Gay, C. C. F., Buffalo, New York (15).
Gibbes, L. R., Charleston, South Carolina (1).
Gibbon, J. H., Charlotte, North Carolina (3).
Gibbs, Wolcott, Cambridge, Massachusetts (1).
*Gillespie, W. M., Schenectady, New York (10).
Gillmore, Q. A., Jr., New York, New York (13).
Gilman, Daniel C., New Haven, Connecticut (10).
*Gilmor, Robert, Baltimore, Maryland (1).
Glynn, James, Geneva, New York (1).
Gold, Theodore S., West Cornwall, Connecticut (4).
Goodwin, William F., Richmond, Virginia (10).
*Gould, Augustus A., Boston, Massachusetts (11).
*Gould, B. A., Boston, Massachusetts (2).
Gould, B. A., Cambridge, Massachusetts (2).
*Graham, James D., Washington, District of Columbia (1).
Gray, Asa, Cambridge, Massachusetts (1).
*Gray, James H., Springfield, Massachusetts (6).
Green, Traill, Easton, Pennsylvania (1).
*Greene, Benjamin D., Boston, Massachusetts (1).
Greene, Samuel, Woonsocket, Rhode Island (9).
*Griffith, Robert E., Philadelphia, Pennsylvania (1).
Grinnan, A. G., Orange Court House, Virginia (7).
Grote, Augustus, R. Buffalo, New York (15).
Guyot, Arnold, Princeton, New Jersey (1).

H.

*Hackley, Charles W., New York, New York (4).
Hadley, George, Buffalo, New York (6).
Haldeman, S. S., Columbia, Pennsylvania (1).
*Hale, Enoch, Boston, Massachusetts (1).
Hall, James, Albany, New York (1).
Hall, N. K., Buffalo, New York (7).
Hamlin, A. C., Bangor, Maine (10).
Hammond, George T., Newport, Rhode Island (14).
Hance, Ebenezer, Morrisville, Pennsylvania (7).
Hand, Thomas J., Baltimore, Maryland (12).
Hanover, M. D., Cincinnati, Ohio (13).

*Hare, Robert, Philadelphia, Pennsylvania (11).
*Harlan, Joseph G., Haverford, Pennsylvania (8).
*Harlan, Richard, Philadelphia, Pennsylvania (1).
Harman, Henry M., Baltimore, Maryland (12).
*Harris, Thaddeus W., Cambridge, Massachusetts (1).
Harrison, B. F., Wallingford, Connecticut (11).
*Hart, Simeon, Farmington, Connecticut (1).
Hartshorne, Henry, Philadelphia, Pennsylvania (12).
Harvey, Charles W., Buffalo, New York (15).
Harvey, Leon F., Buffalo, New York (15).
Haven, Samuel F., Worcester, Massachusetts (9).
*Hayden, H. H., Baltimore, Maryland (1).
Hayes, George E., Buffalo, New York (15).
*Hayward, James, Boston, Massachusetts (1).
Henry, Joseph, Washington, District of Columbia (1).
Herzen, W., Columbus, Ohio (15).
Hickok, M. J., Scranton, Pennsylvania (11).
Hickok, W. C., Burlington, Vermont (16).
Hilgard, Eugene W., Oxford, Mississippi (11).
Hilgard, Julius E., Washington, District of Columbia (4).
Hill, S. W., Hancock, Lake Superior (6).
Hill, Thomas, Cambridge, Massachusetts (3).
Hitchcock, Charles H., New York, New York (11).
*Hitchcock, Edward, Amherst, Massachusetts (1).
Hitchcock, Edward, Amherst, Massachusetts (4).
Hoadley, E. S., Springfield, Massachusetts (13).
Homes, Henry A., Albany, New York (11).
Horsford, E. N., Cambridge, Massachusetts (1).
*Horton, William, Craigville, Orange Co., New York (1).
Hough, Franklin B., Lowville, New York (4).
Hough, G. W., Albany, New York (15).
*Houghton, Douglas, Detroit, Michigan (1).
*Howland, Theodore, Buffalo, New York (15).
Howell, Robert, Nichols, New York (6).
Hubbard, Oliver P., Hanover, New Hampshire (1).
*Hunt, Freeman, New York, New York (11).
Hunt, George, Providence, Rhode Island (9).
*Hunt, E. B., Washington, District of Columbia (2).
Hunt, Thomas S., Montreal, Canada (1).

Hubbert, James, Richmond, Province of Quebec (16).
Hungerford, Edward, Burlington, Vermont (10).
Hyatt, James, Bangall, New York (10).

I.

*Ives, Thomas P., Providence, Rhode Island (10).

J.

Jackson, Charles T., Boston, Massachusetts (1).
Jenkins, Thornton A., Washington, District of Columbia (7).
Jillson, B. C., Nashville, Tennessee (14).
*Johnson, W. R., Washington, District of Columbia (1).
Johnston, John, Middletown, Connecticut (1).
*Jones Catesby Ap. R., Washington, District of Columbia (8).
Joy, C. A., New York, New York (8).
Judd, Orange, New York, New York (4).

K.

Keely, G. W., Waterville, Maine (1).
Keep, N. C., Boston, Massachusetts (13).
Kerr, W. C., Davidson College, North Carolina (10).
Kimball, J. P., New York, New York (15).
King, Mary B. A., Rochester, New York (15).
Kirkwood, Daniel, Canonsburg, Pennsylvania (7).
Kite, Thomas, Cincinnati, Ohio (5).

L.

Lapham, Increase A., Milwaukie, Wisconsin (3).
*Lasel, Edward, Williamstown, Massachusetts (1).
Lattimore, S. A., Lima, New York (15).
Lauderdale, John V., Geneseo, New York (10).
Lawrence, George N., New York, New York (7).
Lea, Isaac, Philadelphia, Pennsylvania (1).
Le Conte, John L., Philadelphia, Pennsylvania (1).
Le Conte, John, Columbia, South Carolina (3).
Le Conte, Dr. Joseph, Columbia, South Carolina (3).
*Lederer, Baron von, Washington, District of Columbia (1).

Lee, John R., Buffalo, New York (15).
Leonard, A. M., Lockport, New York (15).
Lesley, J. P., Philadelphia, Pennsylvania (2).
Lesley, Joseph, Jr., Philadelphia, Pennsylvania (8).
Letchworth, William P., Portage, New York (15).
*Lieber, Oscar M., Columbia, South Carolina (8).
*Lincklaen, Ledyard, Cazenovia, New York (1).
Lindsley, J. B., Nashville, Tennessee (1).
*Linsley, James H., Stafford, Connecticut (1).
Little, George, Oakland, Mississippi (15).
Litton, A., St. Louis, Missouri (12).
Locke, Joseph M., Cincinnati, Ohio (13).
Locke, Luther F., Nashua, New Hampshire (7).
Logan, William E., Montreal, Canada (1).
Loomis, Elias, New Haven, Connecticut (1).
Loomis, L. C., Wheeling, West Virginia (9).
Loomis, Silas L., Washington, District of Columbia (7).
Loosey, Charles F., New York, New York (12).
Lord, John, Stamford, Connecticut (13).
Lovering, Joseph, Cambridge, Massachusetts (2).
Lothrop, Joshua R., Buffalo, New York (15).
Lunn, William, Montreal, Canada (11).
Lyman, Chester S., New Haven, Connecticut (4).
Lyman, B. S., Philadelphia, Pennsylvania (15).
Lyman, Henry, Montreal, Canada (11).
Lynch, P. N., Charleston, S. C. (2).

M.

Marissal, F. V., Fall River, Massachusetts (14).
Marsh, O. C., New Haven, Connecticut (15).
Marshall, Charles D., Buffalo, New York (15).
Marshall, Orasmus H., Buffalo, New York (15).
M'Conihe, Isaac, Troy, New York (4).
McRae, John, Camden, South Carolina (3).
Mahan, D. H., West Point, New York (9).
Marcy, Oliver, Evanston, Illinois (10).
*Marsh, Dexter, Greenfield, Massachusetts (1).
*Mather, William W., Columbus, Ohio (1).

Mauran, J., Providence, Rhode Island (2).
Mayhew, D. P., Ypsilanti, Michigan (13).
Maynard, Alleyne, Cleveland, Ohio (7).
Meade, George G., Philadelphia, Pennsylvania (15).
Means A., Oxford, Georgia (5).
Meek, F. B., Washington, District of Columbia (6).
Meigs, James A., Philadelphia, Pennsylvania (12).
Miles, Henry H., Lenoxville, Canada East (11).
Miller, Samuel, New Haven, Connecticut (14).
Minifie, William, Baltimore, Maryland (12).
Mitchell, Maria, Poughkeepsie, New York (4).
Morgan, DeWitt C., Baltimore, Maryland (14).
Morgan, Lewis H., Rochester, New York (10).
Morris, D., Ellingham, Connecticut (14).
Morris, J. R., Houston, Texas (11).
Morris, John G., Baltimore, Maryland (12).
*Morton, S. G., Philadelphia, Pennsylvania (1).
Munroe, Nathan, Bradford, Massachusetts (6).
Murray, David, New Brunswick, New Jersey (11).

N.

Nason, Henry B., Beloit, Wisconsin (13).
Nelson, Cleland K., Annapolis, Maryland (12).
Newberry, J. S., New York, New York (5).
Newcomb, Simon, Washington, District of Columbia (13).
*Newton E. H., Cambridge, New York (1).
Newton, Hubert A., New Haven, Connecticut (6).
Newton, Robert S., New York, New York (15).
*Nicollett, J. N., Washington, District of Columbia (1).
Niles, W. H., Cambridge, Massachusetts (16).
*Norton, J. P., New Haven, Connecticut (1).
Norton, W. A., New Haven, Connecticut (6).
Nye, A. H., Buffalo, New York (15).

O.

*Oakes, William, Ipswich, Massachusetts (1).
Oliver, James Edward, Lynn, Massachusetts (7).
*Olmsted, Alexander F., New Haven, Connecticut (4).

*OletmDds, enison, New Haven, Connecticut (1).
*Olmsted, Denison, Jr., New Haven, Connecticut (1).
Ordway, John M., Providence, Rhode Island (9).

P.

Packard, A. S. Jr., Salem, Massachusetts (16).
Paine, Cyrus F., Rochester, New York (12).
Painter, Minshall, Lima, Pennsylvania (7).
Palmer, Everard, Buffalo, NewYork (15).
Parker, Henry E., Hanover, New Hampshire (11).
*Parkman, Samuel, Boston, Massachusetts (1).
Parmelee, Dubois D., New York, New York (15).
Parvin, Theodore S., Iowa City, Iowa (7).
Pease, Francis S., Buffalo, New York (15).
Peck, Edward W., Burlington, Vermont (16).
Peck, William G., New York, New York (13).
Peirce, Benjamin, Cambridge, Massachusetts (1).
Peirce, James M., Cambridge, Massachusetts (11).
Perkins, George R., Utica, New York (1).
Perkins, Maurice, Schenectady, New York (15).
Perry, John B., Brookline, Massachusetts (16).
*Perry, M. C., New York, New York (10).
Phelps, Almira L., Baltimore, Maryland (13).
Phelps, Charles E., Baltimore, Maryland (13).
Pierce, Henry M., New York, New York (15).
Pierrepont, H. E., Brooklyn, New York (14).
Plant, I. C., Macon, Georgia (3).
*Plumb, Ovid, Salisbury, Connecticut (9).
Poole, Henry W., Boston, Massachusetts (14).
Pope, Charles A., St. Louis, Missouri (12).
*Porter, John A., New Haven, Connecticut (14).
Powell, Samuel, Philadelphia, Pennsylvania (13).
Prescott, William, Concord, New Hampshire (1).
Pruyn, J. V. L., Albany, New York (1).
Pugh, Evan, Centre Co., Pennsylvania (14).
Putnam, F. W., Salem, Massachusetts (10).

Q.

Quincy, Edmund, Jr., Dedham, Massachusetts (11).

R.

Rankin, Alexander T., Buffalo, New York (15).
Ranney, Orville W., Buffalo, New York (15).
Rauch, J. H., Chicago, Illinois (11).
Raymond, R. W., New York, New York (15).
Redfield, John H., Philadelphia, Pennsylvania (1)
*Redfield, William C., New York, New York (1).
Rice, Clinton, New York, New York (7).
Richardson, Horace, Boston, Massachusetts (12).
Ritchie, E. S., Boston, Massachusetts (10).
Robertson, Thomas D., Rockford, Illinois (10).
Robinson, Coleman T., Buffalo, New York (15).
Rochester, Thomas F., Buffalo, New York (15).
Rockwell, Alfred P., New Haven, Connecticut (10).
*Rockwell, John A., Norwich, Connecticut (10).
Rodman, William M., Providence, Rhode Island (9).
Rogers, Fairman, Philadelphia, Pennsylvania (11).
*Rogers, James B., Philadelphia, Pennsylvania (1).
Rogers, W. A., Alfred, New York (15).
Rogers, W. B., Boston, Massachusetts (1).
Rood, O. N., New York, New York (14).
Roosevelt, Clinton, New York, New York (11).
Rumsey, Bronson C., Buffalo, New York (15).
Rumsey, Dexter P., Buffalo, New York (15).
Russell, Andrew, Ottawa, Canada West (11).
Rutherford, Louis M., New York, New York (13).

S.

Safford, J. M., Nashville, Tennessee (6).
Safford, Truman H., Chicago, Illinois (13).
Sanborn, Francis G., Andover, Massachusetts (13).
Sargent, Rufus, Auburn, New York (10).
Scarborough, George, Sumner, Kansas (2).
Schanck, J. Stillwell, Princeton, New Jersey (4).

Schofield, J. M., Washington, District of Columbia (13).
Schott, Arthur C. V., Georgetown, District of Columbia (8).
Schott, Charles A., Washington, District of Columbia (8).
Scudder, Samuel H., Cambridge, Massachusetts (13).
Sellstedt, Laurentius G., Buffalo, New York (15).
Seward, William H., Auburn, New York (1).
Sexton, Jason, Buffalo, New York (15).
Seymour, M. H., Montreal, Canada (11).
Shaefer, P. W., Pottsville, Pennsylvania (4).
Sherwood, Albert, Buffalo, New York (15).
Sias, Solomon, Charlotteville, New York (10).
Sill, Elisha N., Cuyahoga Falls, Ohio (6).
*Silliman, Benjamin, New Haven, Connecticut (1).
Silliman, Benjamin, New Haven, Connecticut (1).
Sillsbee, E. A., Salem, Massachusetts (14).
Skinner, John B., Buffalo, New York (15).
Smith, A. D., Providence, Rhode Island (14).
*Smith, J. V., Cincinnati, Ohio (5).
Smith, James Y., Providence, Rhode Island (9).
*Smith, Lyndon A., Newark, New Jersey (9).
Snell, Eben S., Amherst, Massachusetts (2).
*Sparks, Jared, Cambridge, Massachusetts (2).
Spencer, Charles A., Buffalo, New York (14).
Spring, Charles H., Boston, Massachusetts (13).
Squier, George L., Buffalo, New York (15).
Stanard, Benjamin A., Cleveland, Ohio (6).
Stearns, Josiah A., Boston, Massachusetts (10).
Stearns, William F., Oxford, Mississippi (13).
Steele, Oliver G., Buffalo, New York (15).
Steiner, Lewis H., Frederick City, Maryland (7).
Stevenson, Charles L., Charlestown, Massachusetts (14).
Stewart, William W., Buffalo, New York (15).
Stimpson, William, Chicago, Illinois (12).
Stoddard, O. N., Oxford, Ohio (7).
Stone, Edwin M., Providence, Rhode Island (9).
Storer, D. H., Boston, Massachusetts (1).
Storer, Frank H., Boston, Massachusetts (13).
Sullivant, W. S., Columbus, Ohio (7).
Swallow, G. C., Columbia, Missouri (10).
Swinburne, John, Albany, New York (6).

T.

*Tallmadge, James, New York, New York (1).
*Taylor, Richard C., Philadelphia, Pennsylvania (1).
*Teschemacher, J. E., Boston, Massachusetts (1).
Thomas, Calvin F. S., Buffalo, New York (15).
Thompson, Alexander, Aurora, New York (6).
Thompson, Aaron R., New York, New York (1).
*Thompson, Z., Burlington, Vermont (1).
*Thurber, Isaac, Providence, Rhode Island (9).
Tillman, S. D., New York, New York (15).
Tingley, J., Meadville, Pennsylvania (15).
Tingley, Joseph, Greencastle, Indiana (14).
Tolles, Robert B., Boston, Massachusetts (15).
Torrey, John, New York, New York (1).
*Totten, J. G., Washington, District of Columbia (1).
Townsend, Franklin, Albany, New York (4).
*Townsend, John K., Philadelphia, Pennsylvania (1).
*Troost, Gerard, Nashville, Tennessee (1).
Trowbridge, W. P., New York, New York (10).
*Tuomey, M., Tuscaloosa, Alabama (1).
Turner, Henry E., Newport, Rhode Island (14).
*Tyler, Edward R., New Haven, Connecticut (1).
Tyler, P. B., Springfield, Massachusetts (13).
Tyson, Philip T., Baltimore, Maryland (12).

U.

Upham, G. B., Boston, Massachusetts (14).

V.

*Vancleve, John W., Dayton, Ohio (1).
Van Pelt, William, Williamsville, New York (7).
*Vanuxem, Lardner, Bristol, Pennsylvania (1).
Vaux, William S., Philadelphia, Pennsylvania (1).
Verrell, A. E., New Haven, Connecticut (16).
Viele, Henry K., Buffalo, New York (15).
Vose, George L., Paris Hill, Maine (15).
Vought, John H., Buffalo, New York (15).

W.

*Wadsworth, James S., Genesee, New York (2).
Wagner, Tobias, Philadelphia, Pennsylvania (9).
Walker, Joseph, Oxford, New York (10).
Wales, Torrey E., Burlington, Vermont (16).
Wales, William, Fort Lee, New York (15).
Walker, Joseph, Oxford, New York (10).
*Walker, Sears C., Washington, District of Columbia (1).
*Walker, Timothy, Cincinnati, Ohio (4).
Ward, Henry A., Rochester, New York (13).
Warner, H. G., Rochester, New York (11).
Warren, G. K., Washington, District of Columbia (12).
*Warren, John C., Boston, Massachusetts (1).
*Webster, H. B., Albany, New York (1).
*Webster, J. W., Cambridge, Massachusetts (1).
*Webster, M. H., Albany, New York (1).
Webster, Nathan B., Kenansville, North Carolina (7).
Wenz, J., New Orleans, Louisiana (15).
West Charles E., Brooklyn, New York (1).
Wheatland, Henry, Salem, Massachusetts (1).
*Wheatland, Richard H., Salem, Massachusetts (13).
Wheatley, Charles M., Phœnixville, Pennsylvania (1).
Wheeler, T. B., Montreal, Canada (11).
Wheildon, W. W., Charlestown, Massachusetts (13).
White, Henry H., Harrodsburg, Kentucky (14).
Whitney, Asa, Philadelphia, Pennsylvania (1).
Whitney, H. H., Montreal, Canada (11).
Whitney, J. D., Northampton, Massachusetts (1).
Whitney, William D., New Haven, Connecticut (12).
Whittlesey, Charles, Cleveland, Ohio (1).
Willard, Emma, Troy, New York (15).
Williams, Henry W., Boston, Massachusetts (11).
Williams, Matthew, Syracuse, New York (13).
Williamson, R. S., San Francisco, California (12).
Willmarth, A. F., New York, New York (15).
Wilson, Daniel, Toronto, Canada (10).
Winchell, Alexander, Ann Arbor, Michigan (3).
*Woodbury, L., Portsmouth, New Hampshire (1).

Worthen, A. H., Springfield, Illinois (5).
Wright, A. W., New Haven, Connecticut (14).
Wright, Chauncey, Cambridge, Massachusetts (9).
*Wright, John, Troy, New York (1).
Wurtele, Louis C., Lennoxville, Canada East (11).
Wurtz, Henry, New York, New York (10).
Wyckoff, C. C., Buffalo, New York (15).

Y.

Youmans, E. L., Saratoga Springs, New York (6).
*Young, Ira, Hanover, New Hampshire (7).

The above list contains five hundred and twenty names, of which one hundred and five are of deceased members.

MEMBERS ELECTED

AT

THE BURLINGTON MEETING.*

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†Abbe, Cleveland, Washington, District of Columbia.
Adams, J. S., Burlington, Vermont.
Allen, Joseph D., Burlington, Vermont.
*Angell, James B., Burlington, Vermont.
Barnes, Lawrence, Burlington, Vermont.
Benedict, G. G., Burlington, Vermont.
*Benedict, G. W., Burlington, Vermont.
*Bigelow, George H., Burlington, Vermont.
Buckham, M. H., Burlington, Vermont.
Burton, O. A., Burlington, Vermont.
Cannon, L. G. B., Burlington, Vermont.
Carpenter, Walter, Burlington, Vermont.
Catlin, Albert L., Burlington, Vermont.
Catlin, H. W., Burlington, Vermont.

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* Those marked with an asterisk have paid the assessment and signed the constitution; those marked thus (†) have paid the assessment; those marked thus(‡) have declined; the others have not responded.

Davis, Mial, Burlington, Vermont.
Day, S. F., Ballston, New York.
*Delano, B. L., Boston, Massachusetts.
‡Dodge, O. A., Burlington, Vermont.
Edmands, George F., Burlington, Vermont.
Englesby, L. B., Burlington, Vermont.
Hickok, Henry P., Burlington, Vermont.
Hickok, James W., Burlington, Vermont.
*Hickok, William C., Burlington, Vermont.
Hopkins, Theodore A., Burlington, Vermont.
Howard, D. D., Burlington, Vermont.
*Hubbert, James, Richmond, Province of Quebec.
Huntington, Samuel, Burlington, Vermont.
Lewis, James, Burlington, Vermont.
Linsley, D. C., Burlington, Vermont.
Loomis, Henry, Burlington, Vermont.
Marsh, L., Burlington, Vermont.
*Niles, W. H., Cambridge, Massachusetts.
Noyes, Carolus, Burlington, Vermont.
*Packard, A. S., Jr., Salem, Massachusetts.
‡Parsons, W. L., Le Roy, New York.
*Peck, Edward W., Burlington, Vermont.
†Perry, John B., Brookline, Massachusetts.
Pierce, J. S., Burlington, Vermont.
Pomeroy, J. N., Burlington, Vermont.
Roberts, Daniel, Burlington, Vermont.
Shaw, William G., Burlington, Vermont.
Shedd, James A., Burlington, Vermont.
Underwood, Levi, Burlington, Vermont,
Van Duzee, Mary K., Buffalo, New York.
Vansiclew, F. M., Burlington, Vermont.
*Verrell, A. E., New Haven, Connecticut.
*Wales, Torrey E., Burlington, Vermont.
Walling, H. F., New York, New York.
‡Worcester, J. H., Burlington, Vermont.

ADDRESS

OF

PROFESSOR J. S. NEWBERRY,

PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE YEAR 1867,

ON RETIRING FROM THE DUTIES OF PRESIDENT.

Gentlemen of the American Association for the Advancement of Science: —

Every day of our lives we hear that this is an age of *progress;* and that it is so we find evidence at every turn. The rapidity with which effects follow causes in human events, the celerity with which the plan is carried into execution, gives to a *year*, in the experience of one of the present generation, the practical value of a lifetime in ages past. Much labor has been expended on the exposition of the causes of the mental activity of the present age, and of the grand achievements which have attended it; and yet the key to the whole enigma is to be found in the universal adoption of the comparatively new system of inductive reasoning. It would be foreign to my purpose to attempt to illustrate or defend this proposition, and I must, therefore, trust to its acceptance without argument, while we pass to consider that branch of the subject which more immediately demands our attention.

Although the progress of the age to which I have referred has been a matter of wonder and delight to all students of humanity and civilization, many of our best men have been somewhat alarmed and dizzied by it; and, while accepting the achievements of modern industry and thought as full of present good and future promise, they are not a little concerned lest our railroad speed of progress should lead to its legitimate consequences, a final crash — not of things material, but of those

of infinitely more value — of opinions and of faith. As often as it is boasted that this is pre-eminently an age of progress, that boast is met by the inevitable "but" (which qualifies our praise of all things earthly) "it is equally an age of scepticism." For the truth of this assertion the proof is nearly as palpable as of the other; and in view of the ruthlessness with which the man of the present removes ancient landmarks and profanes shrines hallowed by the faith of centuries, it is not surprising that many of the good and wise among us should deplore a liberty of thought leading, in their view, inevitably to license, and mourn over this wide-spread scepticism as an evil and inscrutable disease that has fallen upon the minds and hearts of men.

Now for every consequence there must be an adequate cause; and while confessing the fact of this modern lack of faith, I have thought that a few moments given to an analysis of it, and an attempt to trace it to its source, might not be wholly misspent, — might possibly, indeed, result in giving a grain of encouragement to those who look with distrust and dread upon the investigations and discussions which now occupy so large a portion of the time and thought of our men of science.

If the wheels of time could, for our benefit, be rolled back, and we could see in all its details the civilization of Europe three or four hundred years ago, we should find that our so much respected ancestors, who fill so large a space on the page of history, were little better than barbarians. Among the English, the French, the Germans, Spanish, and Italians we should find a phase of civilization which, excepting that it included the elements — as yet but imperfectly developed — of a true religious faith, is scarcely to be preferred to that of the Chinese. Aside from the vast difference perceptible between the civilization of that epoch and ours, as exhibited in the political condition of the people, in their social economy and morals, the general intellectual darkness of the period referred to could not fail to impress us both profoundly and painfully. Out of that darkness and chaos have come, as if by magic, all our modern democracy, with its individual liberty and dignity, all our civil and religious freedom, all our philanthropy and benevolence, all our diffused comfort and luxury, most of our good manners and good morals, and all the splendid achievements of our modern scientific investigation.

It is unnecessary for me here to describe in detail the origin and growth of modern science. That has been so well done by Dr. Whewell, that all men of education are familiar with the steps by which the

grand, beautiful, and symmetrical fabric formed by the grouping of the natural sciences has acquired its present lofty proportions.

Previous to the period when the Baconian philosophy was accepted as a guide in scientific investigation, but one department of science had attained a development which has any considerable claim to our respect. Mathematics, both pure and applied, had been assiduously cultivated from the remotest antiquity, and with a degree of success which has left to modern investigators little more than the elaboration of the thoughts of their predecessors. In Metaphysics, — which had claimed even a larger share of the attention of the scholars of antiquity, — little progress had been made. Perhaps I am justified in saying little progress was possible, inasmuch as in the light of all the great material discoveries of modern times the metaphysicians of the present day are debating, with as little harmony of opinion, the same questions that divided the rival schools of the Greeks. Each successive generation has had its two parties of idealists and realists, who have discussed the intangible problems which absorbed the great minds of Plato and Aristotle with a degree of enthusiasm and energy — and it may be of acrimony — which seems hardly compensated by any expansion of the human intellect or amelioration of the condition of mankind.

Of the *physical sciences* we may say that, except Astronomy, no one had an existence prior to the time of Bacon. There were men of vast learning, and much that was *called* science in the mass of reported observation that had been accumulating from century to century, until it had become "*rudis indigestaque moles;*" but in this — though it constituted the pride of universities, the intellectual capital with which the savant thought himself rich, and that on which the professional man depended for success — there was far more error than truth, and its study was sure to mislead and likely to injure. In these circumstances the task before the scientific reformer was one more difficult than that of clearing the Augean stables; no less, in fact, than to seat himself before this great heap of rubbish, this mass of truth and error, — of the sublimest philosophy with the wildest fiction, — to patiently winnow out the grains of truth, and from infinitesimal facts build up a fabric that should have a sure foundation below, and beauty and symmetry above. What more natural, then, than that the process adopted in winnowing this chaff-heap should be that which had given success to the only true science of the period? — that the mathematical touchstone should be the test by which every grain was tried? And such

precisely was the course pursued; perhaps we may even say the only one practicable. Provided with this test, the reformer was compelled to rejudge upon its merits every proposition submitted to him, and accepted only as true such as could be demonstrated. The materials which composed the science to be reformed naturally fell into several categories. First, — That which had been *demonstrated* to be true. Second, — That which was *demonstrable*. Third, — That which was *probable*. Fourth, — That which was *possible*, and Fifth, — That which was *impossible*. Of these he systematically rejected all but the first and second classes. And this, in few words, has been the method adopted, not only in the purification of old science, but in the creation of new.

It will be seen at a glance, that in this process, all that was contrary to the order of nature (supernatural or spiritual) was necessarily excluded; and it was taken for granted that the mathematical or logical faculty of the human mind was capable of solving *all* the problems of the material universe. Sir William Hamilton and others have demonstrated the inadequacy of mathematical processes as a guide to human reason, and a moment's thought will show us that our boasted intellect is incapable of grasping even all the material truths which are plainly presented to it. To illustrate: as we scan the heavens of a clear evening, we recognize the fact that we stand, as it were, on a point in space, where our field of vision is limitless; the heavenly bodies stretching away into the realms of obscurity, and becoming invisible only through the imperfection of our organs of vision. Bringing to our aid the most powerful telescopes, we are apparently as far as ever from reaching the limits of the universe; and when we endeavor to *conceive* of such a limit, the reasoning faculty finds itself incapable of grasping either of the two alternatives offered to it, one or the other of which must be true. The universe must be either limited or limitless. But no man can conceive of a universe without a limit; and if it be regarded as terminated by definite boundaries, the imagination strives in vain to fill the void which reaches beyond. In fact, we stand here face to face with infinity, and recognize the fact that the infinite exists without the power to comprehend it.

The same is true of time. We cannot conceive of its beginning or its end. All things which come within the scope of our senses are limited in duration and circumscribed in space; and though we prate flippantly of the infinite, the pretence that we can grasp it is simply idle talk.

Conducted on such a plan, it was inevitable that scientific investigations should be narrow and materialistic in their tendency. No matter how strong the probability in favor of the truth of a certain proposition, — though the whole fabric of society were based upon its acceptance, and it formed the foundation of civil and moral laws; even though it controlled the actions of the philosopher himself, — if not proved consistent with nature's physical and material laws it must be rejected as unworthy to enter into the construction of the edifice he was erecting. In his great task of undoing the work of blind, unreasoning faith, and wild, illogical speculation, all the fruit of such faith or speculation must be looked upon as matter valueless to his hand. We may even go further and say that were it true that the Supreme Intelligence *had* created the material universe, and by special providence modified or thwarted the general laws through which that universe was governed, such divine supervision and such miraculous interposition must necessarily have been ignored.

Let it not be inferred, however, that each and all of the great men who have been engaged in this work of scientific reformation were necessarily driven to be impious iconoclasts, or that, in their efforts to emancipate themselves from time-honored errors, they necessarily prostituted the liberty they gained to selfish or sensual purposes. On the contrary, the most important advances which the human intellect has made within these later centuries have been due to the efforts of men of the purest and most conscientious character, — men whose lives were devoted with the utmost singleness of purpose to determine *what is truth*, — men who, knowing that all truth must be consistent with all other truth, were willing to go whithersoever it should lead. If it shall prove that they have been occupied with "mint, anise, and cumin," omitting the "weightier matters of the law," it is also true that in no other way could the material laws of the universe be thoroughly investigated than by making them the subjects of an absorbed and undivided attention. It would be as just to impugn the motives and decry the merits of the maker of our almanacs, because his mathematical calculations were not interlarded with moral maxims, as to reproach the student of natural phenomena because he did his work so well, and left to others the co-ordination of the results of his efforts with the accepted dogmas of religious faith.

And it is not true, in any sense, that these devotees of science have lived in vain; for to them we mainly owe the fact that man is not only wiser now than formerly, but that he is better and happier.

In justice to the man of science we must claim for him the position of co-laborer with, and indispensable ally to, the philanthropists and moralists; for from no source have they drawn richer lessons, stronger arguments, or more eloquent illustrations than from his discoveries.

And yet, while conceding conscientiousness and purity of motive to the vast majority of our men of science, and acknowledging the contributions they have made, and are making to human happiness; compelled by my sense of justice to defend their spirit, approve their methods, admire their devotion, and assert their usefulness, I cannot deny that the tendency of modern investigation is decidedly materialistic. All natural phenomena being ascribed to material and tangible causes, the search for and analysis of these causes have begotten a restless activity and an indomitable energy which will leave no stone unturned for the attainment of their object. But while this is apparent, and, indeed, inevitable, as has been seen from the sketch of the growth of modern science, I am far from sharing the alarm which it excites in the minds of many good men. Nor would I encourage or excuse that spirit of conservatism — to call it by no harsher term — which, for the safety of a popular creed, would, by any and all means, repress, and, if possible, arrest investigations that may, it is feared, become revolutionary and dangerous.

Such opposition, in the first place, must be fruitless. All history has proved that persecution by physical coercion or obloquy is powerless to arrest the progress of ideas, or quench the enthusiasm of the devotees of a cause approved by their moral sense. The problems before our men of science *must* be solved in the manner proposed, if human wisdom will suffice for the task. In every department of science are men actuated simply by a thirst for truth, whom neither heat nor cold, privation nor opposition, will hold back from their self-appointed tasks. We may, therefore, accept it as a finality, that this problem will be carried to its logical conclusion.

In the second place, if possible, the arrest of scientific investigation would be not only undesirable, but an infinite calamity to our race. As has been so often said, truth is consistent with itself. If, therefore, our faith in this or that is based on truth, we have no cause for fear that this truth will be proved untrue by other truths. And more than this: it seems to me that, in the reach and thoroughness of this material investigation, we may hope for such demonstration of the reality of things immaterial as shall produce a deeper and more universal *faith* than has ever yet prevailed.

Through this very spirit of scepticism which pervades the modern sciences we are compelled to exhaust all material means before we can have recourse to the supernatural. When, however, that is done, and men have tried patiently and laboriously, but in vain, to refer all natural phenomena to material causes, *then*, having proved a negative, they will be compelled to accept the existence of truth not reached by their touchstone, and faith be recognized as the highest and best knowledge.

That such will be the result is the confident expectation of many of the wisest of the scientific men whose influence is looked upon with such alarm by those who, in their anxiety for their faith, demonstrate its weakness.

Already, as it seems to me, scientists have reached the wall of adamant — the *inscrutable* — that surrounds them on every side, and, ere long, we may expect to see them return to that heap of chaff from which the germs of modern science were winnowed, with the conviction that there were left buried there other germs of other and higher truths than those they gleaned, — truths without which human knowledge must be a dwarfed and deformed thing.

A few illustrations from the many that might be cited will suffice to show the materialistic tendency of modern science. In "Pure Philosophy," — as the students of Psychology are fond of styling their science, — the names alone of Comte, Buckle, Herbert Spencer, Mill, and Draper will suggest the more prominent characters of the school they may be said to represent. The most conspicuous feature in the "Positive Philosophy" of Comte is the effort it exhibits to co-ordinate the laws of mind with those of matter. Spencer is a thorough-going mental Darwinist, who considers the highest attributes of the human mind, the loftiest aspirations of the soul, as only developed instincts, as these were but developed sensations. Mill, more guarded, more fully inspired with the spirit of the age, — which *believes* nothing, and is a foe to speculation, — leaves the *history* of our faculties to be written, if at all, by others; takes them as they are, but reasons of conscience and free-will with an independence of popular belief that savors more of the material than the spiritual school. Buckle wore himself out in a vain chase after an *ignis fatuus*, an inherent, inflexible law of human progress, and hence of human history. Draper is a developmentist, but not a Darwinian. With him civilization is a definite stage in the growth of mind; a degree of development to which it is impelled by a *vis a*

tergo, not unlike, in kind, to that which evolves from the germ, the bud, the leaf, the flower, and the fruit in plant-life, — a development which, when unchecked and free, will be regular and inevitable, but which is so modified by the accidents of race, climate, soil, geographical position, etc., as to render it difficult to say whether the rule or the exception has, in his judgment, greatest potency. If he were a consistent Darwinist, the accidents of development would be its law.

Among the students of "Social Science," — a new and important member of the sisterhoood of sciences, — as in most of the other departments of modern investigation, two groups of devotees are found; one patiently and conscientiously studying the problems of social organization, inspired with the true spirit of the Baconian Philosophy, ready to follow whithersoever the facts shall lead, and having for their object that noblest of all objects, the increase of human happiness. The other class of investigators, in whom the bump of destructiveness is largely developed, would be delighted to tear down the whole fabric of society, and abrogate all laws, both human and divine. Looking upon man as literally the creature of circumstances, as an inert atom driven about by material forces, conscience and responsibility are by them repudiated, and laws and penalties regarded simply as relics of barbaric despotism. The dreary soul-killing creed of these fatalists is fortunately so repugnant to the reason and feelings of the majority of men, that there is little danger that their efforts will reach their legitimate conclusion in throwing society into a state of anarchy and chaos.

In Theology or Biblical Science, the tendency of modern investigation is so distinctly felt, that I need only refer to it. The spirit of independent criticism, so noticeable elsewhere, is still more conspicuous here; assuming sometimes the form of derisive scepticism, but oftener of cold, passionless judgment on the reported facts of sacred history, or the psychological phenomena of religious faith, studied simply as scientific problems.

The names of Strauss, Renan, and Colenso will suggest the results to which men, possibly honest, are led by this so-styled "enlightened and emancipated spirit of inquiry;" while "Ecce Homo" and cognate productions may be considered as the fruit of this spirit, tempered by a very liberal but apparently sincere faith.

Aside from these more marked examples of the decided "set" in the tide of modern religious opinions, we everywhere see evidences

that no part of the religious world is unmoved by it. In every sect and section an impulse is felt to substitute for abstract faith, the "faith without works," — rather a characteristic of the religion of our fathers, and not unknown at present, — that other faith which is evidenced *by* works. In other words: in our day more and more value is being attached to *this life*, as a sphere for religious effort and experience. With what propriety, I leave to the individual judgment of my auditors; the faith of every sect and man is coming to be respected and valued precisely in the ratio of the purity, unselfishness, and active sympathy in the life produced by it.

While, therefore, we have less now than formerly of the self-centred and fruitless piety of the old deacon, who excused his avarice by proclaiming that "business was one thing and religion another, and he never allowed them to interfere," in place of that we have many an Abou Ben Adhem, and all the splendid exhibitions of modern philanthropy.

Though the golden mean displayed in the life and words of Christ is far better than either extreme, I cannot but think the present religious condition of the world is better than any which has preceded it.

In Ethnology, — the pre-historic history of the human race, — the researches of a large number of investigators who are devoted to its study have made interesting and important additions to our knowledge; but it cannot be denied that the result of such investigation has been to create general distrust of our previously accepted chronology, and give an antiquity to man such as the scholars of a previous generation would have looked upon as not only unwarranted but impious. It should be said, however, that our preconceived opinions of the antiquity of the human race — like those of the age of the earth itself — were based upon no solid foundation in nature, history, or revelation; and that our system of chronology was a matter of convention, about which there has been a wide latitude of opinion among the scholars of all ages.

In regard to the *origin* of man, — whether by special creation or by development, — we may confidently assert that modern investigation has given us no new light. Among those who have accepted the theory of a special creation, and have differed only in regard to the number of species and their places of origin or centres of creation, there has been such a diversity of opinion that all confidence in the reality and value of the bases of their reasoning has been lost.

Among the advocates of a multiplicity of species and diversity of origin we have from Blumenbach to Agassiz almost every number between fifteen and three as that of distinct species of the human race, scarcely any two writers advocating the same number. We may, therefore, very fairly infer that the facts upon which their conclusions are founded are not of a very clear and unmistakable character.

The subject of the origin of the human race brings us into the domain of zoölogy, and opens the wide question of the origin of species, which, of late years, has been shaking the moral and intellectual world as by an earthquake. While the various writers upon the origin of the human race were gathering with so much industry, and reporting with so much eloquence the proofs of a diversity of origin, the Darwinian hypothesis comes in and refers, not only all the human family, but all classes of animals and plants, to an initial point in a nucleated cell.

It would be impossible for any one to discuss in a fair and intelligent manner the great question of the origin of species, in anything less than a bulky volume. The merest mention is, therefore, all we can give to it at the present time. Although the appearance of Darwin's book on the Origin of Species communicated a distinct shock to the prevalent creeds, both religious and scientific, the hypothesis which it suggests, though now for the first time distinctly formularized, was by no means new; as it enters largely into the less clearly stated development theories of Oken, Lamarck, De Maillet, and the author of the "Vestiges of Creation." There was this difference, however, that in the developmental theories of the older writers the element of *evolution* had a place; the process of development had its main-spring in an inherent growth, or tendency, such as produces the evolution of the successive parts in plant-life, while, according to Darwin, the beautiful symmetry and adaptation which we see in nature is simply the form assumed by plastic matter in the mould of external circumstances.

Although this Darwinian hypothesis is looked upon by many as striking at the root of all vital faith, and is the *béte noire* of all those who deplore and condemn the materialistic tendency of modern science, still the purity of life of the author of the "Origin of Species," his enthusiastic devotion to the study of truth, the industry and acumen which have marked his researches, the candor and caution

with which his suggestions have been made, all combine to render the obloquy and scorn with which they have been received in many quarters peculiarly unjust and in bad taste. It should also be said of Mr. Darwin that his views on the origin of species are not inconsistent with his own acceptance of the doctrine of Revelation; and that many of our best men of science look upon his theory as not incompatible with the religious faith which is the guide of their lives, and their hope for the future. To these men it seems presumption that any mere man should restrict the Deity in His manner of vitalizing and beautifying the earth. To them it is a proof of higher wisdom and greater power in the Creator that He should endow the vital principle with such potency that, pervaded by it, all the economy of nature, in both the animal and vegetable worlds, should be so nicely self-adjusting that, like a perfect machine from the hands of a master maker, it requires no constant tinkering to preserve the constancy and regularity of its movements.

This much I have said in view of the possible acceptance of the Darwinian theory by the scientific world. I should have stated *in limine*, however, that the Darwinian hypothesis is not, and can never be fully accepted by the student of science who is inspired with the spirit of the age. From the nature of things it can be proved only to a certain point, and while we accept that which is, or can be, proven, — and for it sincerely thank Mr. Darwin, — that which is hypothesis, or based only upon probabilities, we reject, as belonging in the category of mere theories, to disprove or purify which the modern scientific reform was inaugurated. Much, too, may be said against the sufficiency of "natural selection in the struggle of life," from observations made upon the phenomena of the economy of nature. Necessarily, the action of the Darwinian principle must be limited to the individual, be literally and purely selfish; and if it can be proved that a broader influence pervades the created world, that something akin to benevolence enters into the organization of the individual, — something which benefits others and not himself, — one single fact establishing this truth would hurl the entire Darwinian fabric to the ground, or rather restrict it to its proper bearing upon the limits of variation, and the mooted question of "what is a species?"

One of the most potent influences in the perpetuation of species is fecundity in the individual, whereas we see in social insects the econ-

omy of the community is best served by a total loss of this power in the great majority of the individuals which compose it. This objection will perhaps be met by the Darwinians with the assertion that the community, in fact, constitutes an individual; but I must confess that I find it difficult to comprehend how the sterility of the workers in ants and bees was ever introduced through the medium of modified descent, the Darwinian method, or how it is kept up from generation to generation among those individuals which have no posterity to inherit their peculiarities of structure.

The Honey Ants of Mexico offer additional difficulties. Among them a portion of the community secrete honey in the abdominal cavity until they resemble small grapes, and these individuals, during the winter, are despatched in succession to furnish food for the other members of the colony. How, by modified descent, is this honey-making faculty transmitted, when those who possess it are systematically destroyed?

A still harder nut for the Darwinians to crack is furnished in a fact stated by Dr. Stimpson, that among the crustacea, which do not live in communities, a very large proportion of the individuals of a numerically powerful species pass their lives as neuters or undeveloped females.

Another element in nature's economy, which at first sight suggests an objection to the Darwinian theory, is that of *beauty*, which affects others far more than the possessor. This is considered by the Darwinians simply as an attraction to the opposite sex, but as a fact we find that in the larval condition of some insects — a condition in which no propagation is effected — varieties of form and combinations of color exist which appeal to our sense of beauty scarcely less forcibly than in the perfect insects.

Again, the origin of life is left completely untouched by the Darwinian hypothesis, and so long as the vital principle resists, as it has done, all the efforts of theorists and experimenters to bring it within the category of material forces, so long we must regard the world of life as including elements not amenable to the laws which control simple inert matter.

Upon this question of the origin of life so much is being done and said that you will expect a word of reference to it at my hands, yet little more can be reported as the result of modern research than that the origin of life is as great a mystery as ever. You will all remem-

ber how, a few years since, we were startled by the announcement of the discovery of the generation of the "*Acarus Crossii;*" and, while our original distrust of the accuracy of the observations of Mr. Crosse was strengthened by the failure of subsequent experimenters to reproduce his results, our unbelief is further confirmed by the unanimity of all the more modern and intelligent devotees of spontaneous generation in the assertion that life can only originate in its simplest form, that of a unicellular organism. There is no Darwinist who will concede the possibility of an animal as highly organized as an *Acarus*, with body, head, limbs, digestion, and senses, all more or less complete, being the product of spontaneous generation and not the result of slow and gradual development.

Still farther; it is known that the animal kingdom rests upon the vegetable as a base. Animals being incapable of assimilating inorganic matter could not exist without plants. Plants must therefore have preceded animals, and the fruit of spontaneous generation must be a protophyte and not a protozoan.

Yet, notwithstanding its difficulties, there are to-day men, respectable by their numbers and attainments, who are believers in spontaneous generation; but it is with this proviso, — which leaves the mystery as great as ever, — that only from *organic* matter can organisms be produced. So that to the original and primary appearance of life upon the earth, modern science has given us not the slightest clew.

As I have said, the materialists have so far utterly failed to coordinate the vital force with those which we designate as material. The beautiful and important discoveries which have followed researches into the correlation and conservation of forces by pointing to a unity of all the forces in the material world have naturally prompted efforts to centralize, with electricity, magnetism, and chemical affinity, that which we know as vital force. But a moment's reflection will show us how far removed is this vital force from all others with which it has been compared.

The nicest manipulations of chemical science will probably fail to detect a difference in composition between the microscopic germs of two cryptogamous plants. Each consists of the same elements, — carbon, nitrogen, hydrogen, and oxygen, in nearly or quite the same proportions. Both may be planted in a soil which laborious mixture has rendered homogeneous, and subsequently supplied with the same pabulum, and yet, in virtue of some inscrutable, inherent principle,

one develops an humble moss, and the other rises into the beauty, symmetry, and even grandeur of a tree fern. The same lesson is taught by the spermatozoa of the mouse and the elephant. Indeed, all the phenomena which attend the reproduction of species are totally at variance and incompatible with those which mark the action of material laws. Why, in physical circumstances differing *toto cœlo*, does the germ produce a plant or animal so closely copying the parent? and whence this tenacity of purpose in the germ which reproduces, through a long line of posterity, the trivial characteristics of a remote ancestor? Even within our limited observation, we have been struck by the reappearance in the grandchild of the voice, the gesture, the stature, the features, or some other marked peculiarity of his grandsire. Whence comes the force of the axiom that "blood will tell"? — and how incomprehensible that, by the action of only material laws, mental force, or, it may be, moral infirmity, is transmitted from generation to generation, in spite of the system of infinitesimal dilution through which it passes!

And now, even with this hurried and sadly imperfect exposition of the tendency of modern science, the time at our command has been consumed. Before leaving the subject, however, I crave your indulgence for a word to those who, wholly absorbed in the study of the laws which regulate the material universe, are so deeply impressed with their universality and potency that they forget that law is but another name for an order of sequence, and has in itself no force. These are they who, in their pride in the achievements of the human intellect, fail to realize that the universe furnishes conclusive proof that all our philosophy, all our logic, all our observation, are utterly inadequate to solve the problems that are presented to us, — inadequate not simply from the limited nature of our powers of observation, but because the human mind, though forced to confess the existence of the infinite, is utterly unable to grasp it; and that while the logic of reason and the logic of numbers suffice for a qualified understanding of the manner in which material forces work, of the origin and nature of these forces we are and must ever remain ignorant, unless gifted with higher powers than we now possess. As has been stated, seen from the stand-point of our modern materialists, and judged by the criteria which they have adopted, spiritual existence and supernatural phenomena, even if as all-pervading as the most devout religionist believes, must, from *a priori* considerations, be utterly ignored. Of those who

are thus led by their regard for the dignity of material laws to reject the idea of a creative and overruling Deity, I would ask, Is not man himself a disturbing element in your universe? Whatever may be said in regard to man's free-agency, and however confidently it may be asserted that his will is but the resultant of the various motives that operate as distinct forces upon it, consciousness lies at the basis of all reasoning; and the conduct of every man proves that he accepts this axiom. As he issues from his door, he is conscious, beyond all argument, that it is in his power to turn to the right or to the left; and while he holds himself responsible for his volition, he cannot blame us if we ascribe to him free-agency. Man is, therefore, an independent power in the universe. He wills and creates. The locomotive is as truly his creation as himself, fashioned from the dust of the earth and vitalized by the breath of the Almighty, is the work of His hands. If, therefore, all the realm of nature is controlled through material laws, by forces that, like attraction, electricity, chemical affinity, etc., act in an invariable and inflexible way, in this universe man is a stupendous anomaly; and unless he can be degraded from his position of pre-eminence in this material world, the boldest and most irreverent of modern philosophers will strive in vain to dethrone the Great Creator from the rule of the universe, or from His place in the hearts and minds of men.

In consequence of the absence of President F. A. P. Barnard in Europe, an arrangement was made according to which Professor Newberry delivered the address at Burlington, and President Barnard is expected to give his own at the next meeting in Chicago, Illinois.

PROCEEDINGS

OF THE

BURLINGTON MEETING, 1867.

COMMUNICATIONS.

A. MATHEMATICS, PHYSICS, AND CHEMISTRY.

I. MATHEMATICS AND ASTRONOMY.

1. Communication of Vibrations. By Benjamin Pierce, of Cambridge, Mass.

(abstract.)

About a year ago, my attention was drawn by Mr. Henry Waterman, of Hudson, New York, to a curious case of interchange of vibration between two pendulums. The pendulums were of equal weights and lengths, and hung from different points of a horizontal thread, which was perpendicular to their planes of vibration. A similar class of phenomena was studied experimentally about the beginning of the century by the celebrated *savans*, but it has never been investigated mathematically.

I have undertaken to consider the general case of the communication of vibrations between any number of vibrating bodies. I have reached the seemingly paradoxical result, that in a mathematical sense there is no such phenomenon. The mathematical formulas, rigidly interpreted, give us as many different states of possible vibration to each system as it contains different vibrating bodies. Each of these states might exist by itself, and, unless it were for the resistances of friction and so forth,

would be permanently invariable, without any appearance which would suggest a communication of vibrations. The times of vibration of the different states would be different. Every possible state of vibration of the system can be decomposed into these elementary states, and shown to be an aggregate of them. As there is no communication of vibration in either of the elementary states, there is none in the aggregate. *The apparent* communication is, in reality, a phenomenon of interference of coexisting states of vibration which have different periods of vibration.

Thus in the case of Mr. Waterman's two pendulums, one state of vibration is that in which the two pendulums are in the same phase of vibration, so that they vibrate as one pendulum, a little longer than either of them, as is evident from the mode of suspension. The other state of vibration is that in which the two pendulums are in opposite phases, and, in this case, the time of vibration is a little less than that which belongs to either pendulum. When these two states are combined with equal amplitudes of vibration, each pendulum will come to rest at certain intervals, and alternates in such order and magnitude of succession as to satisfy the law of the preservation of power.

The same phenomenon would happen if the two pendulums had been restrained by the mutual connection of a spring, so that they could not recede very perceptibly from the same apparent phase of vibration. But in this case, the state of opposite vibration would be replaced by that in which the spring would be constantly subject to compression and the reverse. A clock, constructed with two such pendulums, would be subject to two different states, and would be liable to pass from one to the other, under circumstances which the observer could not regulate. I believe that this is the cause of the capricious change of late in the clock of the Cambridge Observatory. Were a clock to be constructed with three, four, five, six, or more pendulums, the necessary effect of such construction would be to introduce a corresponding number of different rates which would embarrass observation, and not to give one mean uniform rate, which would be the average of the rates of all the pendulums.

Were two clocks attached to the same pier, they would necessarily affect each other's rates in the same way, so that it is quite important in an astronomical observatory, to place the clocks in such isolated positions that there shall be no mutual influence between them.

2. On the Determination of Geographical Latitude from Observations in the Prime Vertical. By William A. Rogers, of Alfred, N. Y.

(abstract.)

That process of determining the geographical latitude of a place is the most advantageous which most completely eliminates instrumental errors and at the same time offers the greatest facilities for observation. It is my design, in this paper, to show that the method originally given by Bessel, and modified by Chauvenet, of deducing the latitude from equations of condition formed from single transits over the prime vertical, is especially adapted, either to the most exact determination in fixed observatories, or for use in topographical surveys, where only transient stations are established.

The following is the order of discussion observed: —

I. Discussion of star places, from the following authorities; viz., Bradley, 1755; Lalande, 1800; Piazzi, 1800; Groombridge, 1810; Bessel, 1825; Argelander, 1830; Struve, 1830; Pond, 1830; Airy, 1840; Robinson, 1840; Henderson, 1840; Airy, 1845; Radcliffe, 1845; Madras, 1850; Airy, 1850; and Airy, 1860.

II. Description of instruments.

III. Order of observation for 1866.

IV. Formation and solution of conditional equations for 1866.

V. Discussion of results for 1866.

VI. Order of observation for 1867.

VII. Formation and solution of conditional equations for 1867.

VIII. Discussion of results for 1867.

IX. Investigation of errors.

X. Discussion of the thesis that "The latitude may be more nearly determined from Fundamental Stars, passing the meridian at widely different distances from the zenith, than from stars passing the meridian near the zenith, taking into account the present uncertainty involved in the declinations of zenith stars."

XI. Some remarks on the availability of this method, as compared with the Zenith Telescope Method, in topographical surveys.

In 1866, no star has been used whose declination is more than 3° less than the latitude.

RESULTS FOR 1866.

φ is assumed $= 42° 15' 19''.2$.

Date.	Position of instrument.	Weight=No. of observations.	$\Delta\varphi$	mean $\Delta\varphi$, with weights.
June 13,	Circle South.	4	$+1''.10$	
14,	Circle North.	4	+1 .08	$+1''.09$
July 14,	C. S.	4	—0 .27	
15,	C. N.	5	+1 .54	+ .74
July 24,	C. S.			
25,	C. N.	13		+ .35
July 28,	C. S.			
29,	C. N.	6		+1 .17
July 30,	C. S.			
31,	C. N.	12		+ .37
Aug. 1,	C. S.	7	+ .07	
7,	C. N.	3	— .65	— .15
				Mean + .54″

$\varphi = 42° 15' 19''.74$.

For 1867 φ is assumed $= 42° 15' 19''.80$, and the same stars were used as for 1866, together with Fundamental Stars taken from the American Ephemeris, varying in declination between 16° and 32°.

RESULTS FOR 1867.

Date.	Position of Instrument.	Weight=No. of observations.	$\Delta\varphi$	Mean $\Delta\varphi$, with weights.
April 17.	C. S.	12	— ″.01	
	C. N.	9	+ .44	+ ″.18
April 28.	C. S.	5	+ .66	
	C. N.	5	— .27	+ .20
April 28.	C. N.	6	— .06	— .06
June 4,	C. S.	6	+ .50	
	C. N.	6	— .80	— .15
June 5,	C. N.	10	— .06	
June 6,	C. S.	7	— .25	— .11
June 13,	C. S.	8	— .92	
	C. N.	6	+ .83	— .16

Mean $\Delta\varphi = —$ ″.01.

and $\varphi = 42° 15' 19''.79$.

Combining the results for 1866 and 1867 by weights, there results:

$$\varphi = 42^\circ\ 15'\ 19''.78 \pm ''.08.$$

In order to find the effect of an error in observing the time of passage over the prime vertical upon φ, for stars of different declinations, I have selected eight Zenith Stars whose mean declination is 40°, and eight Fundamental Stars whose mean declination is 25° and which for distinction are designated Equatorial Stars. The corresponding hour-angle, ϑ, is, for Zenith Stars 23°, and for Equatorial Stars 59°.

The probable error in ϑ, designated $d\vartheta$, was found by comparing the observed with the computed intervals between the several threads, and from the values of $d\vartheta$ thus found the effect upon $d\varphi$ was computed by the following formula: —

$$d\varphi = \pm \frac{d\,\vartheta}{2} \sin 2\varphi \text{ tang. } \vartheta.$$

RESULTS.

ZENITH STARS.

Star.	δ °	′	No. int'v's compared. ″	$d\vartheta$ ″	$d\varphi$ ″
d Herculis	33	46	35	± .038	± 0.26
12 Canum	39	2	28	.043	.16
b Herculis	39	11	35	.064	.19
b Canum	39	45	35	.074	.24
11 n Herculis	40	51	28	.083	.20
b_1 Bootis	41	17	28	.103	.20
b_2 Bootis	41	21	42	.167	.32
19 Canum	41	33	28	.120	.20
				Mean ±	.22″

EQUATORIAL STARS.

Star.	δ °	′	No. int'v's compared.	$d\vartheta$ s	$d\varphi$ ″
γ Geminorum	16	30	21	± .027	± 0.58
α Bootis	19	52	21	.032	.25
δ Geminorum	22	13	21	.030	.45
μ Geminorum	22	35	21	.032	.46
η Geminorum	27	06	14	.028	.32
α Coronæ Bor.	27	40	14	.031	.34
β Geminorum	28	21	21	.040	.40
α Geminorum	32	11	28	.045	.34
				Mean ±	.43

The following table shows the probable error of $d\varphi$ from all sources

ZENITH STARS.

$d\varphi$	″
From error in observation,	± .22
" " dT = ± .75″,	± .16
" " α = ± 1.5″,	± .32
" " δ = ± 1.2″,	± 1.21
" " reading level,	± .47
" " one div. level,	± .15 × no. div.
Mean ±	.421″

EQUATORIAL STARS.

$d\varphi$	″
From error in observation,	± .43
" " dT = ± .75″,	± .62
" " α = ± 4″,	± .33
" " δ = ± 4″,	± .52
" " reading level,	± .57
" " one div. level,	± .15 × no. div.
Mean ±	.420

It is therefore obvious, that, in these particular observations, the total probability of error as effecting q is very nearly the same for the two cases. Of course with other stars and with other observers, these values would vary somewhat, yet the general result would not, I think, be affected. If now we take into account the great labor involved in the reduction of Zenith Stars, and the uncertainty in the element of proper motion, together with the fact that the use of Fundamental Stars greatly facilitates the increase of the number of observations, it is not doubtful, I think, where the advantage rests.

It is my own experience that eight or ten carefully observed transits over the prime vertical, one half east and one half west of the meridian, and with the instrument in reversed positions, occupying from one to three hours in observation and from one to two hours in reduction, will give the latitude within ".4.

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3. Remarks on Personal Equation in Transit Observations. By G. W. Hough, of Albany, New York.

(abstract).

The "personality" of the eye, in recording transits by the magnetic method, was only considered. The total amount of "personality" may be separated into two distinct portions; viz., that due to the individual, and that due to the instrument.

The individual "personality," all extraneous conditions remaining the same, is not liable to very great change, either from day to day, or year to year. But the "personality" due to the instrument, or the method of observation, is subject to large variations.

The following conclusions were arrived at from the study of numerous experiments extending over a period of seven years. First, — The *absolute* "personality" as deduced from the observation of artificial stars, by means of the chronograph, is found to vary, for the same individual, from year to year, from day to day, and even from hour to hour; but the variation is always very small provided all the conditions of observation are the same. Second. — The absolute "personality" varies with the apparent motion of the moving object. The greater the apparent angular velocity, the less will be the personal equation. Hence it is concluded, that in the observation of transits the personal equation will vary with the declination; and also with the magnifying power of the telescope.

The difference of personality between two observers does not appear to be constant for stars of different magnitudes. From observations and experiments made during the past year, it appears that the difference is the least for bright stars, and greatest for faint ones. If subsequent investigations shall prove this conclusion to be correct, it will probably be found to be due to defective vision. In the observation of faint stars a feeble illumination is used and the wires are sometimes indistinct. But when a bright star is observed with the same illumination, the light of the star itself renders the wires distinctly visible.

The personal equation for the same individual varies with the kind of illumination employed. Observations made with illuminated wires are not directly comparable with those made with illuminated field. Our meridian instruments are so arranged that we can instantly pass from one kind of illumination to another. The transits of a large number of stars were observed, using illuminated wires for the first seven and illuminated field for the last seven, and *vice versa*. It was found that the difference between the two methods was well marked, amounting in the maximum to three tenths of a second of time.

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4. Observations of Venus near Inferior Conjunction. By C. S. Lyman, of New Haven, Conn.

A phenomenon of much interest, and, it is believed, never before observed, was exhibited by the planet Venus at the time of her last inferior conjunction (Dec. 11th, 1866), as seen in the Clark nine-inch equatorial of the Sheffield Observatory, at New Haven, — viz.; The extension of the cusps of the crescent so as to coalesce and form a complete ring of light.

The prolongation of the cusps beyond a semi-circle attracted attention on the 7th, when the planet was $6\frac{1}{4}°$ from the sun, the arc of the crescent being then about 220°. On the 10th, from 10 A. M. to $3\frac{1}{2}$, P. M., the full ring was seen repeatedly by several observers. It was an exceedingly delicate and beautiful object, being, on the side opposite the sun, the merest thread of light. The observation was difficult, on account of the blaze of sunlight in the field, which there were no means of much reducing. Indeed, the full ring could not, in the circumstances,

be seen constantly, but only when the glare of the sun was most diminished, and the atmosphere steadiest for definition. At other times, the crescent was easily seen extending, at least, 270°, and generally 300 or 320°. When latest observed, at $3\frac{1}{2}$ o'clock, Venus was only 1° 8′ from the sun's limb. The nearest approach of centres was on the 11th at 9 hours 52 minutes A. M. No attempt was made to find the planet, as it was then less than 22′ from the limb. On the 12th, however, at 11 hours 30 minutes A. M., the completed ring was again observed, the planet's elongation from the sun's centre being then 1° 51′. Twice, when fortunately a passing cloud shut off the sun for a few moments, leaving the planet still visible, the view was particularly satisfactory. At other times, the coalescence of the cusps was seen, not constantly, but at favorable moments, as on the 10th. About 2 o'clock, the full ring was clearly seen with a Clark five-foot refractor of $4\frac{2}{3}$ inches aperture and power of 90, by placing the telescope so as to have the sun behind a neighboring chimney.

With both telescopes, a marked inequality was noticed in the ring on the northern side, a portion of the delicate crescent being there fainter and slenderer than farther towards the point opposite the sun. This fainter arc was several degrees in extent, and, by estimate, about halfway between the point nearest and that farthest from the sun. It was seen also by Prof. Loomis.

On the 14th, the arc of the crescent was 231°; on the 15th, from 205° to 208°; and on the 18th, 196°. This arc was determined by estimate from cross wires made to quarter the disc, and also by measuring its versed sine with a filar micrometer. Owing to the difficulties of observation, these determinations are not as exact as could be desired, yet, from their general accordance, are believed to be pretty good approximations.

The extension of the cusps beyond a semi-circle has been observed before by Schroeter, Herschel, Mädler, and others, but they do not appear to have had an opportunity of following the planet into so close proximity to the sun as was possible at the late conjunction, and hence failed to observe the completed ring. Had the conjunction in 1866 occurred twenty-four hours earlier, there would have been a transit. Mädler, at Dorpat, in 1849, saw a maximum crescent of 240°, Venus being then 3° 26′ from the sun's centre (its nearest approach).

On the supposition that the phenomenon is due to the refraction of the planet's atmosphere, Mädler made the horizontal refraction, from

his observations, 43′.7. My observations at the late conjunction give, by the same formula, 45′.3 as the mean, from six measurements of the cusps.

II. ACOUSTICS.

1. On the Optical Method of Studying Sound. By Joseph Lovering, of Cambridge, Mass.

When the science of Acoustics is studied by means of the ear exclusively, we judge of the process simply by the result, that is, by the sensation. The optical method of investigation often gives us an insight into the process itself. Sound begins with a stationary vibration in the sonorous body; it is propagated by a progressive undulation; and it ends, physically and mechanically considered, in a vibration of some one of the three thousand nervous filaments discovered by Corti in the labyrinth of the human ear. Whether we regard the sound, therefore, at its origin, in its promulgation, or in the sensation, it is nothing but a vibration; and vibration is motion, and motion is the subject of vision. So that to see sound is only to see the motions which cause it. The only difficulty of seeing sound lies in the fact that the acoustic vibrations are upon a microscopic scale of magnitude, and, by their quick succession, the separate effects of individual vibrations blend into one sensation, in the eye as well as in the ear, by virtue of what is called in both cases the persistency of the impression on the organ of sensation. To overcome the first difficulty a beam of light is reflected from the vibrating body, or a mirror attached to it, which moves *in angle* twice as fast as the body itself, while the motion *in arc* may be amplified to any extent by increasing the length of the beam of light. The second difficulty is surmounted by reflecting the vibrations of the sonorous body itself, or some more visible effect which they originate, from a revolving mirror. By this device of looking at the image of the body, instead of the body itself, its vibrations, which coexist in space, are disentangled from each other, and movement vibrations, hundreds of which succeed each other in a single second of time, are translated into a long belt of space, in which even two successive ones do not overlap.

The optical method of studying sound embraces, in general, Savart's contrivance for discovering and exhibiting the nodal lines of plates by means of sand sprinkled over their surface, the investigation of the nodes and bellies of sounding strings by mounted riders, and of columns of air by a little drumhead suspended in the pipes, and more recently Lissajous' mirrors attached to tuning-forks, etc., Koenig's flames played upon by vibrating columns of air and reflected in a revolving mirror, and, finally, Melde's strings excited by the sympathetic vibration of an attached tuning-fork or bell.

The present communication is confined, however, to Koenig's reflected flames, in which are seen the individual vibrations of an organ pipe; by which can be beautifully demonstrated to the eye: First, — That the number of vibrations increases with the audible pitch; Second, — That coexisting vibrations produce maxima and minima of motion corresponding to the beats which are recognized by the ear; Third, — That one column of air will respond, in sympathetic vibration, to another when there is an agreement between their fundamental notes or some of their harmonics; Fourth, — That two unison-pipes, brought into intimate neighborhood, will move so that the vibrations of the air cross one another and produce silence, as Savart showed experimentally in the case of pendulums of equal length vibrating in company.

This peculiar case of unison-pipes I have made a subject of special investigation. In complex cases, it would doubtless be impossible so to arrange the voices and instruments that the total volume of sound should be multiplied in the same ratio as the number of performers. The effect of a large chorus or a large orchestra will disappoint expectation, from the unavoidable interferences of sound-waves. But in the simple case of two unison-pipes, can they be prevented from silencing each other? The remedy for the evil would be: First, — To sacrifice in a measure the perfection of the unison; or, Second, — to place them at a distance beyond each other's influence; or, Third, — to separate them by one-half of the wave-length which propagates a sound of the given pitch, or by some odd multiple of that quantity. The latter remedy would answer for auditors in the direction of the line which united the two pipes, though not for the audience generally. In studying the effect of position I have made the following experiments, the ear being the judge; or the eye, looking at the broken ribbon of light in the revolving mirror.

I. The pipes are placed side by side.
   1. With similar ends together, they silence each other.
   2. With dissimilar ends together, they silence each other.

II. The pipes are placed with their axes upon the same straight line.
   1. If similar ends are together, whichever of the two ends be selected, they silence one another.
   2. If dissimilar ends are together, they silence each other.

III. The pipes are placed at right angles to one another, with one extremity of each pipe at the angle.
   1. If the ends that are played are at the angle, the pipes reinforce each other.
   2. If the other ends are at the angle, they tend to silence each other.
   3. If dissimilar ends are at the angle, they reinforce each other.

In all these experiments the pipes employed were open at both ends.

Now that science is in possession of this delicate optical method, which requires for its success no nice musical ear, other problems, heretofore settled by assumption, may be brought within the range of demonstration.

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2. On a Method of Measuring Musical Intervals upon a Spiral Projection. By Samuel D. Tillman, of New York, N. Y.

Vibrations, producing the different sounds of the diatonic scale, have fixed numerical relations. Starting from the first or lowest sound, and proceeding upward, the eighth sound is found to harmonize most perfectly with the first; proceeding still upward, the fifteenth is found to harmonize just as perfectly with the eighth, and the twenty-first with the fifteenth. Each of these four sounds are, therefore, regarded as the first in a distinct, but similar, series, embracing seven sounds. The vibrations producing each sound of the first series are, to those causing a similar sound in the second, as 1 to 2. This natural divi-

sion of musical sounds into septaves is not clearly shown when the characters or signs representing these sounds are arranged in one right line, as found in all popular systems of instruction; moreover, the ear, in demanding the addition of the octave, as the terminal note of the diatonic scale, helps to mislead.

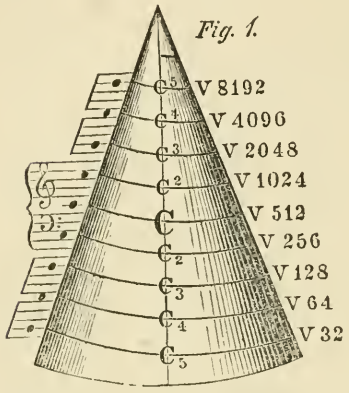


Fig. 1.

To obviate this difficulty, I represent the progress of pitch, from the lowest to the highest musical sound, perceptible to the human ear, by a line passing spirally around a cone, as seen in Fig. 1.

Each ring measures a septave. A right line drawn from the apex to the base of the cone cuts the spiral at each point where there is an apparent return to the tonic by a repetition of the octave. All the sounds known as C are shown. On the right is the number of vibrations producing each, assuming that the middle C has 512, or is the ninth octave of an imaginary sound, having one vibration per second. The French standard pitch requires for this sound 522 vibrations per second. On the left are the positions of all the notes C on the staff, as fixed by the base and treble clefs.

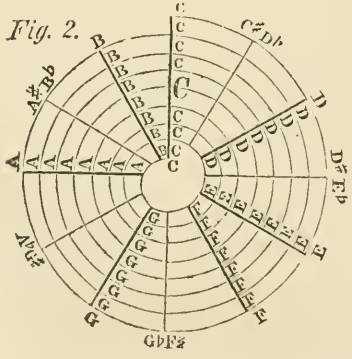


Fig. 2.

Twelve similar right lines, at equal distances around the cone, would represent the intervals of the chromatic scale, as made by keyed instruments; and seen from the top of the cone, they would appear, as shown in Fig. 2, which measures all the intervals made on the largest sized organ.

The true spiral projection, representing a single septave, is shown in Fig. 4. The line CO being the length of a string or pipe giving the sound C; and c O. a similar string or pipe, half as long as the first, which gives a sound an octave higher than the first sound. The perfect concord of these two sounds arises from the fact that every wave of

air producing the lower sound strikes the ear simultaneously with every other wave causing the octave.

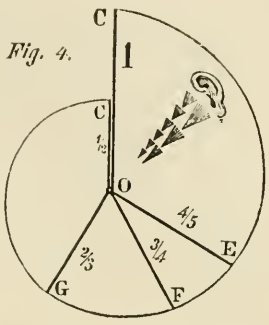


Fig. 4.

The intermediate sounds of the diatonic scale would be measured on the septave by lines proportionate to the length of strings or pipes producing such sounds. Only three are shown at E, F, and G. The ratio of the vibrations producing these sounds respectively with those producing C being as 4 : 5, 3 : 4, and 2 : 3. The generation of a spiral on this plan, to embrace every septave, requires that the length of the radius vector should be doubled with every revolution of the generatrix, and would, therefore, on account of its size, be quite inconvenient. For general use I substitute a true circle for one ring of the spiral, and divide it into twelve equal parts or grades to represent the tempered intervals of one septave, as made by keyed instruments. It resembles the ordinary watch dial, 12 being the starting-point or the tonic of the natural key. The position of the figures on a watch-face being so early learned and so familiar to every one, there is but little difficulty in adapting them to musical intervals. Inverting the circle of figures, its application to the keys of a piano, or an organ, are shown in the annexed illustration, Fig. 5.

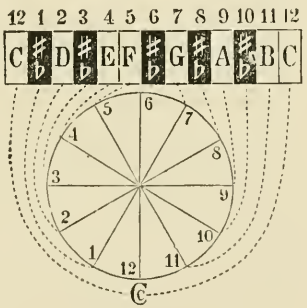


Fig. 5.

Two septaves of keys are shown in Fig. 3. The numbers 12, 2, 4, 5, 7, 9, 11 correspond with the letters designating the notes of the natural key of C, while the numbers 1, 3, 6, 8, 10 designate notes used in other keys. This application of numbers to the twelve sounds embraced in a septave obviates the necessity of sharps and flats which do not properly belong to the tempered system employed on keyed instruments.

Fig. 3.

The position of the numbers used in the key of C, on the staff, as fixed by the base and treble clefs, are shown in Figs. 6 and 7.

Fig. 6.

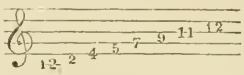
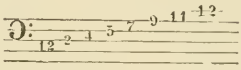


Fig. 7.



These preliminary statements will make plain the use of my Tonometer, which measures to the eye all musical intervals. (The instrument was here presented by the speaker, and illustrated on the blackboard.) It consists of a sheet or plate containing a circle divided into spaces representing the intervals of the true as well as the tempered system. A division of the circle into equal spaces, so as to measure by multiples of one such space all intervals that can be made by modulations, would be so minute as to be of no practical service. I have substituted a near approximation to the true intervals by dividing the circle into fifty-three equal parts called commas. The comma used is the difference between the first and the second intervals of the diatonic scale, expressed by the ratio of $\frac{81}{80}$. Taking the ratio of the air-waves producing each sound of the true septave with those producing the tonic, and deducing the ratio of the several sounds with each other, we have the following ratios of intervals: $\frac{9}{8}$, $\frac{10}{9}$, $\frac{16}{15}$, $\frac{9}{8}$, $\frac{10}{9}$, $\frac{9}{8}$, $\frac{16}{15}$. The first three ratios being nearly as the whole numbers 9, 8, 5, we may measure the so-called major-tone, minor-tone, and semitone intervals of the septave by 9, 8, 5, 9, 8, 9, 5 = 53, or the whole number of units in the circle.

The same circle is also divided into twelve equal parts representing an isotonic temperament of the chromatic scale, applicable, however, to keyed instruments tuned by allotonic temperaments.

Within this fixed circle is a movable circular disk, having upon it the same divisions representing the true and tempered intervals. As the notes of the septave have the same fixed relation, it is evident that the position of the movable tonic at any pitch shown on the fixed circle will determine the position of every other note on the same circle. The notes of the septave represented on the disk are distinguished by the common syllables used in solfeggio, and the numbers by which

they are known in figured base. Within the movable circle, representing the intervals, and in the major mode, is another series of signs, representing the notes of the minor mode. Thus completing the symbols for one key, by turning the tonic sign from C to G, D, A, E, B, and F sharp respectively, we see at a glance the notes belonging to each key in a modulation by sharps. Again, starting from C and passing to F, B flat, E flat, A flat, D flat, and G flat, we find, in turn, the sounds belonging to these several tonics. The employment of numbers in the place of letters renders these changes in modulation much more simple, and obviates the unwarrantable use of the terms "flat" and "sharp." In a modulation by sharps, seven, added to the last tonic, gives the next succeeding one; thus 12, 7, 2, 9, 4, 11, 6. In a modulation by flats, 5 is added; thus we have 12, 5, 10, 3, 8, 1, 6, as the regular order of tonics. Both series begin and end with the same figures. The seven sounds used in each modulation are determined by this simple rule; viz., If the tonic is an odd number, the next two notes are odd, and the remaining four, even; *vice versa*, if the tonic is an even number, the next two notes are even, and the remaining notes odd.

A synopsis of chords expressed by the solfeggio syllables is adapted, by means of the revolving disk, to the twelve different modulations made by keyed instruments.

The relations of sound and color are shown by applying the colors of the solar spectrum to the seven intervals of the septave. Red, made by the lowest number of undulations, represents the tonic; yellow, the mediant; and blue, the dominant. I have elsewhere pointed to the very curious coincidence arising from this arrangement of colors; the darkest color, indigo, falls on the relative minor tonic; and the brightest, yellow, on the brilliant mediant; from which the deduction is made that light, heat, and actinism result from the undulations of the same attenuated medium; that the two forces last named vary inversely as the length of undulations, while the perception of light and color results from the ratio of undulations embraced in a single octave.

The intervals of the three major and three minor common chords are respectively measured by 4, 3, and 5 grades and 3, 4, and 5 grades. Discovering that, in each case, the sum of the squares of the first two numbers was equal to the square of the third number, I was led to represent these triads by right-angled triangles. In *comma* terms the equation is $17^2 + 14^2 = 22^2 + 1$. The same terms show that twelve consecutive fifths overlap seven consecutive octaves, that is, $31 \times 12 = 53 \times 7 + 1$.

Further deductions have been made which are, however, foreign to the purpose of this paper, but this singular relation of lines and angles to the harmony of color, as well as sound, does suggest that there are certain connecting links between form and motion, the discovery of which may reveal, partially, at least, those processes of nature, producing both permanency and growth ; and that, eventually, man may comprehend the operation of those wave-forces which, by harmonious blending, shape cell and crystal and define the forms of leaf and flower.

In conclusion, I would advocate a change in the solfeggio syllables which gives each a vowel termination, and, at the same time, assists the vocalist in determining their harmonic relations. This slight reform only carries out what seems to have been the original intention of the early masters. The Greeks applied to their tetrachords the syllables *Ta, Te, The, Tho.* Although their system was early supplanted by the septave, no improvement in solmization was made until, in the eleventh century, Guido Aretino designated the first six sounds by different syllables. He was led to their use by noticing a marked relation between the ascending sounds given to the first syllables of the following Hymn to St. John: —

Ut queant laxis,
Resonare fibris,
Mira gestorum,
Famuli tuorum,
Solve polluti,
Labii reatum,
Sancte Johannes.

Regarding this discovery as a special revelation to him, he did not venture to complete the scale, which was done long after his time by adding *si.* The consonant ending of two of these syllables was not favorable to prolonged vocal sound. *Ut* was afterward replaced by *do.* The *l* in *sol,* when followed by *la* did not seem so objectionable, and sol has held its place among syllables which have been used in solmization for eight hundred years. Guido's scale commenced on G, and was sometimes designated by the Greek name, *Gamma,* also by *ut,* from whence arose *Gammut*; thus the discarded *ut* has found a permanent place in the name of the scale. The change I propose is the substitution of *To* for *do,* and of *do* for *sol ;* thus *To* will always be found on the Tonic ; *mi* on the Mediant ; and *do* on the Dominant ; and To-

mi-do will express the common chord now known as the *first, third,* and *fifth.* All chords may be indicated by a combination of solfeggio syllables, and numbers only used to designate the twelve grades of the spiral which represent the twelve intervals of the tempered system.

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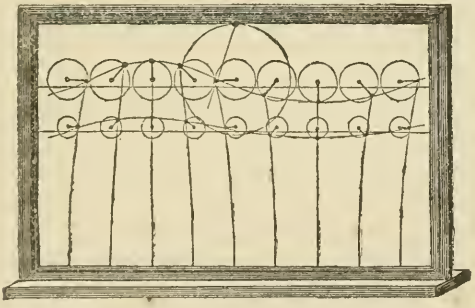
3. On a New Form of Wave Apparatus. By C. S. Lyman, of New Haven, Conn.

The class of waves which this piece of mechanism was designed to illustrate is that whose type is the ordinary ocean wave in deep water. The apparatus exhibits not only the wave profile with its progressive motion, but also the motions taking place below the surface, in the whole mass of liquid affected. Since the motions in the apparatus are essentially the same as in nature, the leading geometrical and dynamical facts pertaining to the theory of waves are presented with completeness, and in their true relations. The wave theory illustrated is that established by Gerstner, Scott Russell, Rankine, and others, and which teaches that, in such waves, all the particles are revolving synchronously, and in the same direction, in vertical circles. An able analytical exposition of it. by Prof. Rankine, is contained in the *Philosophical Transactions* for 1863.*



* It is somewhat singular that this theory, though more than half a century old, has, nevertheless, but just begun to supplant, in the text-books, that which explains wave motion as a vertical oscillation of neighboring liquid columns, as in the two branches of a U-shaped tube, a theory commonly credited to Newton; though Newton, in fact, only used it as a convenient approximative hypothesis for a particular purpose, not as a theory true to nature, remarking in conclusion, "Hæc ita se habent ex Hypothesi quod partes aquæ recta ascendunt vel recta descendunt; *sed ascensus et descensus illo verius fit per circulum.*"

The construction of the apparatus is simple. In front of a plane surface are two series of revolving arms or cranks, the length of the lower ones being half that of the upper. Two elastic wires connect the crank-pins of each series; upright wires also connect each pair of cranks, and pass down through a plate into the base. The cranks all revolve synchronously; they thus keep their relative position, and come into any particular position successively, each in its turn. The relative position of the cranks of each series is such, that the directions of any two, in regular order, differ by the same fraction of a whole revolution that the distance between their axes is of a whole wave length. In the apparatus, the length of a wave is divided into eight equal portions, and hence, the common difference in the directions of the crank-arms is one eighth of a circle, as shown in the figure. The positions of the cranks in each vertical set are always alike. The number of cranks, whether reckoned horizontally or vertically, is arbitrary, — a matter of convenience. Their synchronous revolution is produced by any suitable mechanism, such as toothed wheels, rag-wheels with endless metallic ribbon or chain, or cranks and connecting frame. In the original machine, equal toothed wheels, one on each axis, with intermediate idle-wheels, give the required motion. For small machines the third method is used, as in the model for the Patent Office.

The crank-pins represent as many liquid particles, and the circles behind the crank-pins their orbits. The transverse wires represent lines of equal pressure, or continuous lines of particles, which at rest would be horizontal, and so coincide with the lines drawn just below the centres of the orbits, the upper one of these being the surface line, the lower one a line of particles one ninth of a wave's length below. The upright wires represent lines of particles which at rest would be vertical. Every point in these moving lines describes its own distinct orbit. The spaces between the wires show the varying distortions of sections of water originally rectangular.

The radius of the large circle is made such that its ratio to the radius of a particle's orbit is equal to the ratio of gravity, or the weight of the particle, to its centrifugal force; or, putting R and r for the radii respectively, and t for the time of revolution, we make $R : r :: g : \frac{4\pi^2 r}{t^2}$; hence, $t = 2\pi\sqrt{\frac{R}{g}}$, which is the period of a revolving pendulum whose height is R. Such a pendulum, then, will keep time with the wave.

The force acting on a particle being the resultant of its weight and centrifugal force, if the latter be represented, in intensity and direction by the crank-arm or radius vector of the particle, the former, or gravity, will be represented, similarly, by the vertical radius of the large circle, and the resultant of the two by the third side of the triangle, or a line drawn from the top of this radius to the particle. The wire pendulum represents this resultant, and, like it, is always normal to the wave surface.

The measure of the resultant force being the distance on the wire pendulum from its point of suspension to the wave surface, it is seen that when the particle is at the top of its orbit, the acting force is its weight minus its centrifugal force; when, then, the centrifugal force equals the weight, as in high short waves, the resultant becomes zero, and the particle, no longer held by gravity, flies from the crest in foam.

Since the wire-pendulum is always normal to the wave-curve, its entre of oscillation is the instantaneous centre about which may be described an element of the curve at the point of normalcy. Hence if this circle be rolled along under a horizontal straight line, a point within it, at a distance from its centre equal to half the height of a wave, will describe a trochoid, which is the wave profile. Consequently, the circumference of the rolling circle is equal to the length of a wave; and the period of a wave is that of a revolving pendulum whose height is the radius of the same circle.

If the describing point be taken in the circumference of the rolling circle, the curve is an inverted cycloid. The cycloidal cusp, then, is the limit of sharpness of a wave's crest, the radius of the orbit being, in that case, equal to that of the rolling circle, or, in other words, the particle's centrifugal force equal to its weight. All possible wave profiles, therefore, are trochoids of curvatures ranging between the limits of the cycloid on the one hand, and the straight line on the other, or between the sharp crest breaking in foam and the level of still water. The greater sharpness of the crests than of the troughs, with its cause, is conspicuous in the apparatus.

It is seen also that the crests rise higher above the level of still water than the troughs fall below it. The difference is equal to twice the height due to the orbital velocity of the particle, or is a third proportional to the radius of the rolling circle and the radius of the particle's orbit; that is, putting R and r for these radii respectively, and D for the difference in question,

$$D = \frac{r^2}{R}.$$

The rolling circle is the same for all wave profiles (or surfaces of equal pressure) down to still water, the tracing arm, or orbit-radius, only becoming shorter in a geometrical ratio, with increase of depth. The rate of shortening is approximately one half for each additional depth equal to one ninth of a wave's length; or, more exactly, putting r and r' for the radii respectively of a surface orbit and of one whose middle depth is k, it is

$$r' = r\, e^{\frac{k}{R}},$$

R being the radius of the rolling circle, and e the base of the Naperian logarithms.

The distance of the crank-axes above the horizontal lines on the background corresponds to the distance of the orbit-centres of corresponding particles in wave motion above the position of the same particles when at rest; this distance is a third proportional to the diameter of the rolling circle and the radius of the particle's orbit, or is equal to the height from which a body must fall to acquire the orbital velocity of the particle, or, is equal to the area of the orbit divided by the length of the wave; that is, putting h for this distance, l for the wave's length, v for the orbital velocity, and the other symbols as before,

$$h = \frac{r^2}{2R} = \frac{4\,\pi^2\,r^2}{2\,g\,t^2} = \frac{v^2}{2g} = \frac{\pi\,r^2}{l}.$$

The length of a wave whose period is t is

$$l = 2\,\pi\,R = \frac{g\,t^2}{2\,\pi};$$

the period

$$t = \sqrt{\frac{2\,\pi\,l}{g}} = 2\,\pi\sqrt{\frac{R}{g}};$$

and the velocity of propagation of such a wave

$$V = \frac{l}{t} = \frac{g\,t}{2\,\pi} = \sqrt{\frac{g\,l}{2\,\pi}} = \sqrt{g\,R}.$$

The motion of the wire-pendulum represents the motion of the mast of a raft floating on the wave's surface; the upper portion of each upright wire shows the motion of a long, thin body floating in a vertical position, as a board end down; the varying inclination of the two bodies, or wires, to each other shows the kind of strain produced by

wave-action on a floating body both broad and deep, such as the hull of a vessel.

In shoal water, the orbits are no longer circles, but ellipses or ovals, with the eccentricity increasing as the depth diminishes, while the front slope of the wave becomes increasingly steeper than the back, until the crest finally curls over and breaks in surf.

The apparatus has been patented, and is manufactured by Messrs. E. S. Ritchie and Son, of Boston.

III. PHYSICS AND CHEMISTRY.

1. Tellurium, a Metal. By L. Bradley, of Jersey City, N. J.

By the kindness of Dr. L. Feuchtwanger, of New York, I am permitted to exhibit this piece of Tellurium. He informs me that it was extracted from a combination of Tellurium and Gold, discovered on the Stanislaus River, in Calaveras County, California.

At a recent discussion before the Polytechnic branch of the American Institute, in reference to it, a question arose as to its metallic nature, and its power of conducting electricity. Whereupon I obtained permission to take it and test its conductivity as compared with several other substances. I procured pieces of about the same dimension [half-inch square by three-fourths inch long] of zinc, magnesium, cast iron, graphite, several pieces of coke, black oxide of manganese, sulphuret of antimony, and sulphur; also an appliance for conveniently connecting them, one at a time, into a circuit of short, coarse wire, designed to conduct a current of electricity, generated by four cups of Hill's battery. The battery being arranged as compound battery, i. e., the positive pole of one cup connected with the negative of the next, and so on, and using the tangent galvanometer for intensity, I obtained the following deflections; viz.: —

With no Substance	80°
" Tellurium	80°
" Zinc	80°
" Magnesium	80°
" Cast-iron	80°
" Graphite	79° 5′
" Coke	79° 20′ to 80°
" Manganese	19° 20′
" Sulphuret of Antimony	0°
" Sulphur	0°

With the cups arranged as simple, or quantity battery, — i. e., the positive poles connected, and the negative poles connected, — the deflections were

With	Quantity Galv.	Intensity Galv.
No Substance	28° 20′	62°
Tellurium	26° 50′	62°
Zinc	27° 40′	62°
Magnesium	27°	62°
Cast-iron	27°	62°
Graphite	15° 10′	61°
Coke	20° to 27°	61° 10′ to 62°
Manganese	0	0
Sulphuret of Antimony	0	0
Sulphur	0	0

This shows how little capable a quantity current is of overcoming resistance; for, even the manganese, which, under the intensity current, admitted a deflection of 19° 20′, under this, seemed like a perfect insulator, even by the very sensitive quantity galvanometer.

Tellurium heats readily, though not quite so rapidly as zinc, and it cools a little more slowly.

It is not to be expected that, with pieces so small, and with so weak a battery, very nice and exact results are to be attained; but the foregoing are sufficient to show that Tellurium is a good conductor of both heat and electricity; and we see that it possesses a brilliant metallic lustre.

The question arises, therefore, why is it that chemists, especially those of France, have recently ranked it among the non-metallic substances?

Metallic lustre and conducting power have always been looked to as the distinguishing characteristics of metals. Kane says, "By the combination of these two characters, lustre and conducting power, the metallic, or non-metallic nature of a body is always distinguished."

It is true that Tellurium is not malleable nor ductile, as are many of the metals; neither is bismuth or antimony. Like the non-metallic substances, it unites with *oxygen* to form acid. So do antimony, arsenicum, gold, chromium, manganese, and many other metals. With *hydrogen* it unites, forming a hydruret; so do potassium, arsenicum, and antimony. In short, it possesses the universally admitted distinguishing characteristics of metals; and nothing, either in physical character or chemical behavior, which it does not hold in common with some other metals. I must therefore call it a metal.

2. Preliminary Notice of Experiments on Snow at Temperatures below 32° Fahrenheit. By Edward Hungerford, of Burlington, Vt.

(abstract.)

This paper gave full details of a series of experiments, conducted by the author, to determine the effect of pressure upon snow, at temperatures below the melting point. The experiments raise a serious doubt as to the correctness of the assertion that snow cannot be converted into ice by pressure at those temperatures. By *prolonged pressure* the glacification of the snow was effected under such conditions as did not seem to admit either of the elevation of the temperature of the snow to 32°, or of its liquefaction through depression of the melting point. It is claimed that the prolongation of the pressure gives time for the air to escape from the meshes of the snow, thus permitting intimate contact between the particles, when union takes place, resulting in transparent or semi-transparent ice.* The method of conducting experiments was explained and apparatus exhibited. The important bearing of these experiments on the subject of the glacification of the *névé* and on the theories of regelation leads the author to propose to continue them during the coming winter.

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3. Chemical Diagrams and Derivative Symbols, Illustrating the Prominent Characteristics of Chemical Elements. By Samuel D. Tillman,† of New York, N. Y.

Chemists now recognize at least 64 different kinds of ponderable matter which have not, thus far, been decomposed, and are therefore regarded as simple bodies. Of these 51 are called metals and 13 non-metallic elements. French chemists do not draw the line of distinction so broadly, since several of the non-metallics possess nearly all the characteristics of the metals. They recognize 49 of the elements as metals, and designate the remaining 15 as metalloids. The objection to this classification is, it assumes that all elements which are not metals are *like* metals. Seven of these metalloids are strongly

* This explanation was not so distinctly stated in the paper. — E. H.

† Diagrams and illustrations in this paper, entered to Act of Congress in the year 1867, by S. D. Tillman, in the Clerk's Office of the District Court of the United States for the Southern District of New York.

electro-negative, and in their general behavior bear no resemblance to metals.

On examining the non-metallic elements, it will be found most convenient to classify them according to the state or condition which they assume when isolated.

Three elements are remarkable for their hardness or impenetrability, namely, CARBON, BORON, and SILICON. They are denoted by a pyramid in the centre of the first diagram.

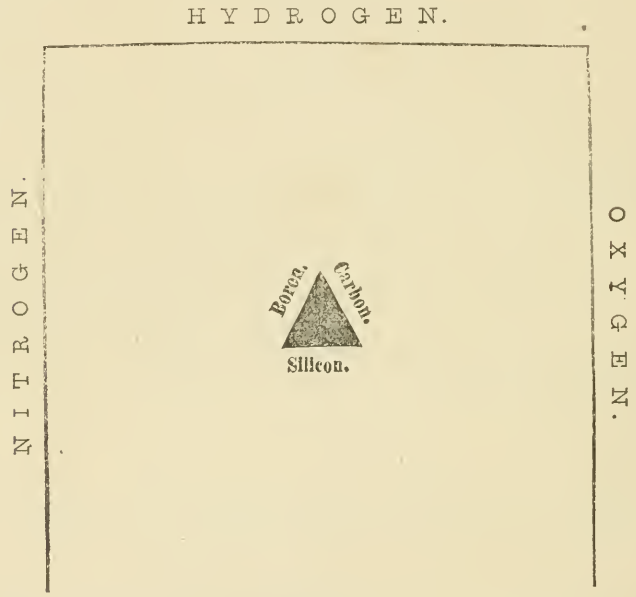


Fig. 1.

The three boundaries of one face of a pyramid will respectively represent these three elements. SILICON or SILICIUM fuses at about 1,450° Centigrade, the melting point of steel. BORON is reduced only at a still higher heat. CARBON, when perfectly isolated and surrounded by substances with which it has no affinity, remains solid and infusible under the highest heat thus far applied.

As the antipodes of these hard elements, we have three gases, which, under the greatest degree of cold and of pressure yet applied to them, have not been reduced to the solid or even to the liquid state. They are OXYGEN, NITROGEN, and HYDROGEN.

The three lines in Fig. 1, furthest from the centre, represent these attenuated elements. To the class of simple gases also belong FLUORINE and CHLORINE which are represented by the lower lines in Fig. 2. Thus the five gases are designated by the five boundary lines of the

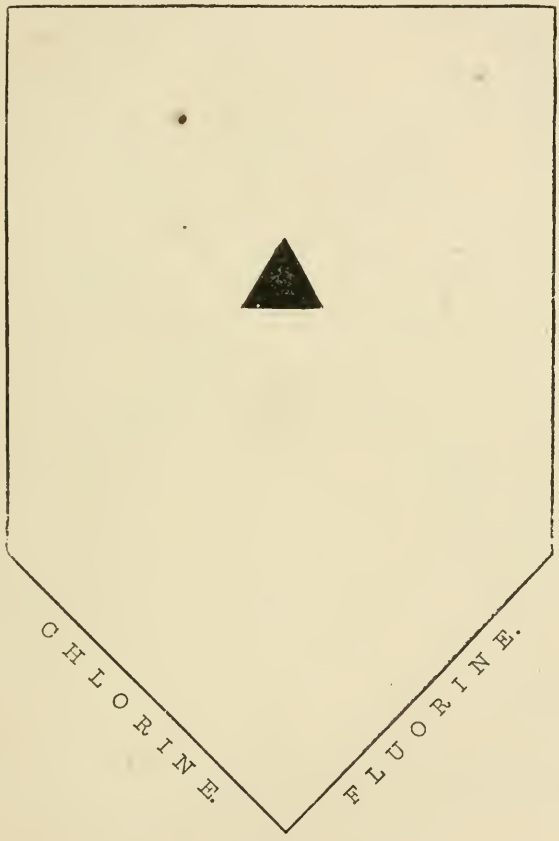


Fig. 2.

diagram. FLUORINE is the only element which has not been obtained in a separate state; nevertheless, considerations, which need not here be presented, justify the assumption that Fluorine, when isolated, is a colorless gas.

CHLORINE is a transparent greenish yellow gas at ordinary tem-

peratures. When subjected to a pressure of about 60 lbs. to the square inch, it becomes a yellow liquid; yet, when cooled to 140° C, it still remains unfrozen.

Between the three hard elements and the five gases, are found five

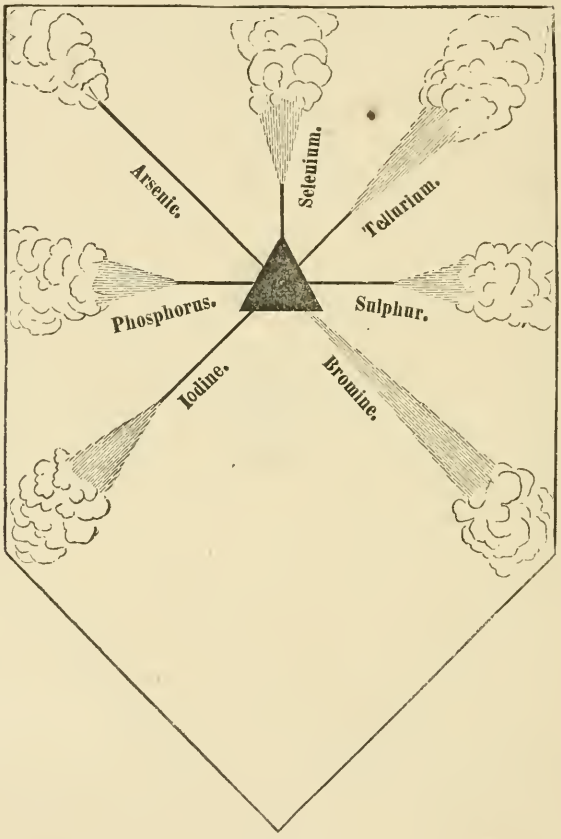


Fig. 3.

non-metallic elements which readily pass from the solid to the gaseous state on being heated, viz., Bromine, Iodine, Sulphur, Selenium, and Phosphorus. If the French view is adopted, we must include as metalloids Arsenic and Tellurium. These *seven* elements are shown in Fig. 3, which is so arranged as to represent the solid state of the element

by a thick line nearest the centre, then the liquid, and lastly, the state of vapor near the outside of the diagram.

It will be observed that Bromine is not represented by a thick line, because at ordinary temperatures it is a liquid. Bromine becomes a solid at 12°.5 C, and boils at 63° C.

Iodine melts at 107° C, and changes into a splendid blue vapor at 175° C.

Sulphur melts at 115 C, and becomes a deep yellow vapor at 440° C. Sulphur has several modifications of form, or different allotropic states, in each of which it is differently affected by heat.

Selenium melts at a little over 100° C. In the crystalline form it softens at 217° C, and does not become completely fluid until above 250° C. Heated in a close vessel, it boils at a little above red heat.

Tellurium, which has the appearance of a metal, fuses a little below 480° C, and at a high temperature becomes vapor.

Arsenic is not known in a liquid state. At 180° C, it begins to volatilize without fusing. This peculiarity is represented by a thick line extending from the centre to the point, where it is shown as a vapor. This element, as well as Tellurium, I prefer to class among the metals.

Phosphorus melts at 45°, and boils at about 299° C.

The metals are solid at ordinary temperatures, with the exception of Mercury, a fluid which freezes at 39° C, and becomes a colorless vapor at about 360° C. A large majority of the metals melt at a high temperature; yet several of the light metals, of the alkaline class, become fluid a little below the boiling point of water.

The fifty-one metals — including Arsenic and Tellurium — are represented by the radial lines in Fig. 4; the shaded line projecting downward from the centre denotes the fluid, Mercury.

This diagram includes all the known elements. It is arranged so as to show with clearness their classification as fifty-one metals and thirteen non-metallic bodies, also their consistencies when in a separate state at ordinary temperatures, thus embracing

5 Gases.
2 Liquids.
57 Solids. Total, 64.

The gaseous elements are again represented by Fig. 5.

Hydrogen, the lightest, is placed at the top; Fluorine and Chlorine,

the heaviest two, at the bottom; Oxygen and Nitrogen have an intermediate position on the sides. Equal parallelograms, projecting from the sides of the figure, represent equal measures or volumes of each gas at the same temperature and pressure; and the wide mark, or bar,

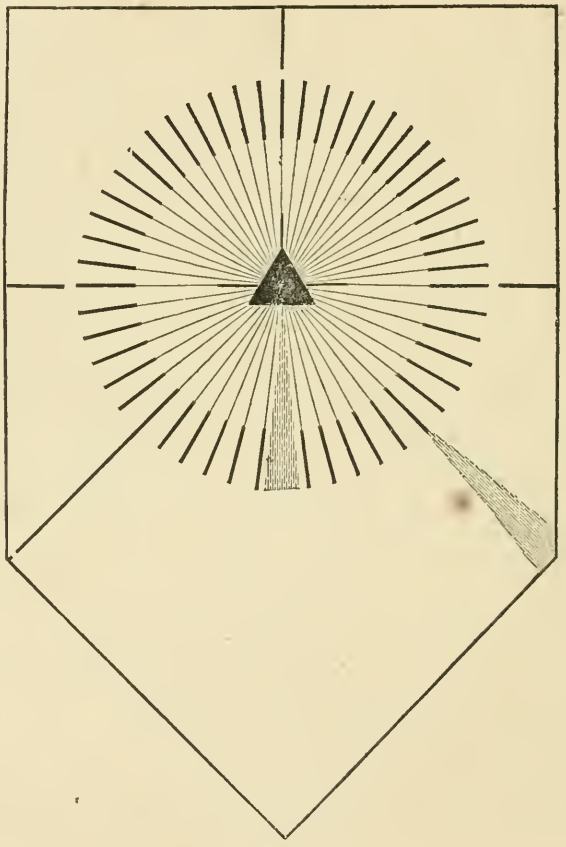


Fig. 4.

within each parallelogram, shows its relative density or specific gravity. Assuming that one volume of Hydrogen weighs 1, then one volume of Nitrogen will weigh 14; one of Oxygen, 16; one of Fluorine, 19; one of Chlorine, 35.5. As these gases unite in equal volumes, or

multiples of equal volumes, in forming chemical compounds, the smallest portion which can enter into combination may be distinguished as an atom, therefore the bars designating the density of the gases may

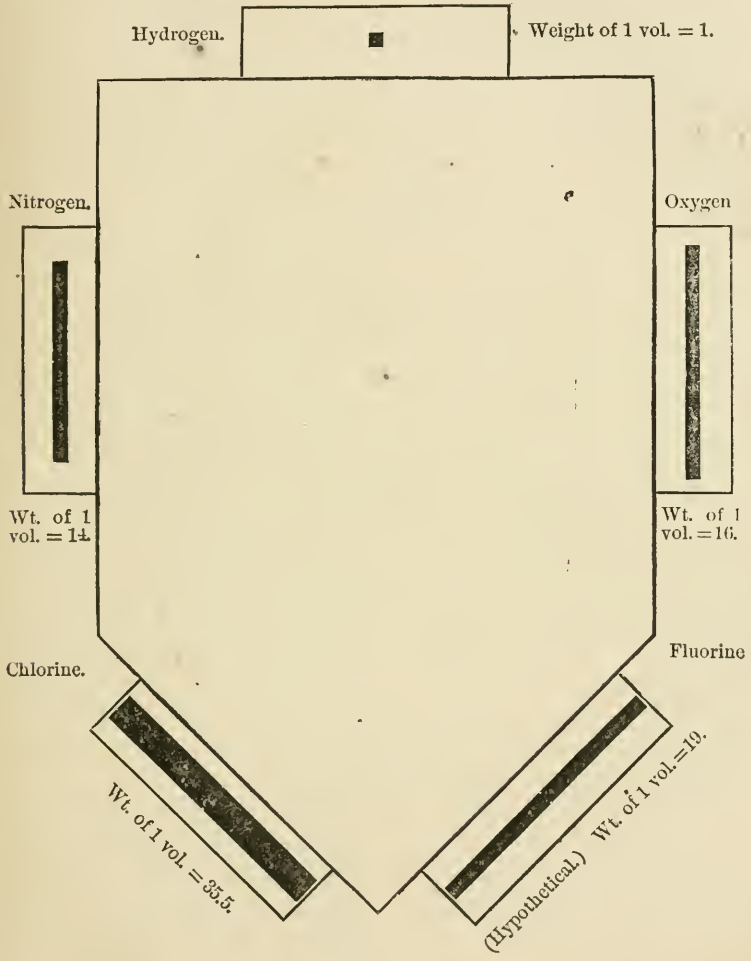


Fig. 5.

be taken as the relative weight of atoms which are supposed to be of equal size. The conception of an atom must not be limited by size

and weight. It is, in fact, a source of force. Several years ago, I advanced the hypothesis that the ultimate atom is a hollow sphere, containing, and surrounded by, the imponderable ethereal element, and incessantly moving to and from its own centre. Whatever may be its condition in chemical combination, it assumes its original form and motion on being released and isolated.

The arrangement of the elementary gases in Figs. 2, 3, and 4 has another important signification. Oxygen unites with all other elements except fluorine, and is electro-negative. From the position of Oxygen passing around the diagram downward and then upward, we find these gases in the order determined by electrolysis, — Hydrogen being electro-positive to the other four.

The non-metallic elements, or metalloids, belonging to the same family are placed, as shown in Fig. 3, in close proximity, so that their atom-holding, or saturating power, in chemical combination, may be clearly understood. Hydrogen, Fluorine, Chlorine, Bromine, and Iodine, having the lowest atom-holding power, are monatomic, or monads. Oxygen, Sulphur, Selenium (also Tellurium), are diatomic, or dyads. Nitrogen, Phosphorus, Boron (also Arsenic), are triatomic, or triads. Carbon and Silicon are tetratomic, or tetrads.

The chemical combination of two gaseous elements and the resulting volume are also illustrated by a series of diagrams. It is supposed that not less than two atoms of each element enter into combination; however, the process is rendered more intelligible by representing the union of single volumes. Fig. 6 shows the combination of a volume of Hydrogen with one of Chlorine, which, under the influence of light, unite without condensation, and form two volumes of hydrochloric acid gas.

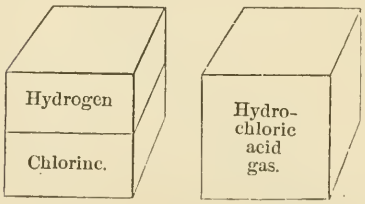


Fig. 6.

Although the resulting product of the union of these gases is not diminished in bulk, yet, at the instant each electro-positive atom seeks an electro-negative, there is expansion. This process of the mating of atoms produces explosion.

Fig. 7 represents two volumes of Hydrogen and one of Oxygen, entering into combination and forming steam, which is condensed to

two volumes, or two thirds of the original bulk of these gases in a separate state.

Below 100° C the steam is condensed to nearly one seventeen hundredth of its volume. As one cubic foot contains 1,728 cubic inches, we may say that two cubic feet of Hydrogen and one cubic foot of Oxygen combine and form two cubic feet of Steam, which may be condensed to about two cubic inches of Water.

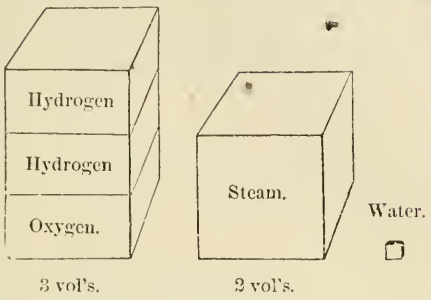


Fig. 7.

Fig. 8 represents three volumes of Hydrogen combining indirectly with one of Nitrogen, and forming two volumes of ammonia. Thus four volumes are condensed to two, the resulting product being one half of the bulk of the combined gases. To express this combination in accordance with the new atomic theory, we should say three atoms of Hydrogen and one atom of Nitrogen combine to form an atomoid of ammonia. By using portions of the principal diagram on a much reduced scale, many of the most important chemical combinations of the non-metallic elements may be represented, and to each may be added the name designating its ultimate constituents. According to the new chemical nomenclature, Fluorine, Chlorine, Bromine, and Iodine, forming the family of halogens, are represented by the four sides of the annexed figure .

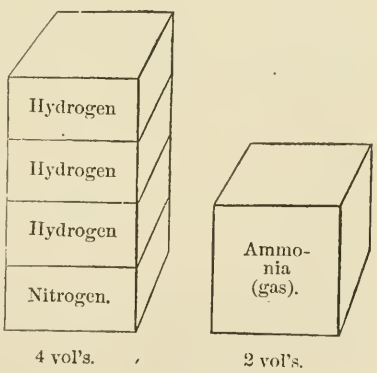


Fig 8..

One atom of Fluorine being *af ;* one of Chlorine, *ad ;* one of Bromine, *ab ;* one of Iodine *av ;* and one of Hydrogen, *al.* I designate the acids

formed by the combination of the several halogens with Hydrogen as follows (the prefix g denotes the gaseous state):

Hydrofluonic acid, H F. *alaf.*

Hydrochloric acid, H Cl. *galad.*

Hydrobromic acid, H Br. *galab.*

Hydriodic acid, H I. *galav.*

Carbon combines in such a variety of proportions with Hydrogen, Nitrogen, and Oxygen, and in many cases assuming with them the gaseous state, I represent it by a line connecting the lower ends of the lines denoting Nitrogen and Oxygen in Fig. 1. Contracting the whole, an atom of Carbon is shown by the following symbol.

The four thick sides of this figure, thus , represent the FOUR GRAND ORGANIC ELEMENTS. Projections from each side will denote the number of atoms of each element in the symbolized chemical body. The following are symbols of some of the most common and important compounds of the non-metallic class.

Water H_2O *elat;* (steam) *gelat.*

Oxygenated water H_2O_2 *elet* or *elt.*

Carbonic oxide gas **C O**. *garat* or *gart.*

Carbonic acid gas $C O_2$ *garet.*

Ammonia $H_3 N$ *gilan.*

Nitric acid $H N O_3$ *alanit.*

Prussic acid $H C N$ *alarn.*

The large class of hydrocarbons are represented by various projections on the following figure ; for instance, Marsh gas, or light carburetted Hydrogen $C H_4$ garol. Similar contractions of that portion of the main diagram, representing all the metals, may be used, thus .

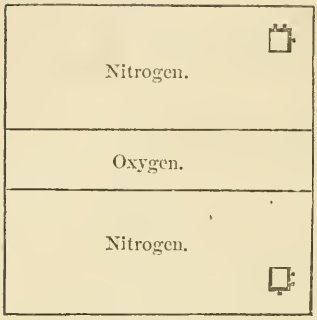
The five metals of the alkalies — viz., Lithium, Sodium, Potassium, Rubidium, and Cœsium — are designated by a star with five points .

The four metals of the alkaline earth, — viz., Barium, Strontium, Calcium, and Magnesium, — by a star with four points .

The consideration of metals and metallic compounds would open too wide a field for the present discussion.

Having treated of true chemical combination and symbolized Water and Carbonic Acid, we are prepared to speak of the mixture of gases by virtue of the law of diffusion. The following figure will convey some idea of the proportion of gases found in common Air, nearly four fifths of which is Nitrogen, and a little more than one fifth, Oxygen.

There are traces of Ammonia, Carburetted Hydrogen, and Nitric-Acid in Air, which are not represented in this figure. Ten thousand parts of common Air contain from three to six parts of Carbonic Acid. The proportion of Water in the atmosphere varies with its temperature. Every 15° C of additional heat in Air doubles its capacity for holding vapor.



Common air.

Fig. 9.

The diagrams now presented to the Association are intended to impress upon the mind of the student the leading characteristics of the non-metallic elements. A strong conviction that Chemistry is second to no other science in importance has impelled me to devise a method for its more general acquisition. If the symbols were firmly fixed in the memory, like the alphabet, or numerical figures, the labor of subsequent combination would be comparatively light. A groundwork, like this, thoroughly laid, will enable a student to erect in his own mind a permanent superstructure. Thus prepared, he will quickly catch the significance of every chemical compound and more readily apply the fundamental principles of the science to the experimental work of the laboratory.

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4. A New Chemical Nomenclature.* By S. D. Tillman, of New York, N. Y.

The present seems very opportune for the introduction of a Nomenclature which will more completely methodize the Science of Chemistry. By such aid, students, who formerly deserted the study because they found themselves gradually sinking into a quagmire of incongruous names, may advance on firm ground, and view with satisfaction and profit the fair fields opened on every side by the distinguished chemists of our own time. The old nomenclature, based on the joint production

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* Read at the meeting of the American Association for the Advancement of Science, held in the City of Buffalo, August, 1866.

of De Morveau, Lavoisier, Berthollet, and Fourcroy, published in 1787, has been frequently amended and enlarged; yet, to preserve the connection and consistency of the whole, names and classifications were retained long after they had lost their original significance. Even the broad line of distinction between acids and salts (made when oxygen acids and neutral salts only were known) gradually diminished with the successive discoveries of acid salts and the promulgation of new views by Davy and Dulong, until it is now no longer recognized by those who regard the whole class of hydracids as true salts. A fatal error was committed at the outset, in attempting to define the acids containing most and least oxygen, by adopting as terminals (rendered into English) *ic* and *ous*, and the corresponding terminals *ate* and *ite* for salts. Subsequent discoveries of higher and lower oxides involved the necessity of using, as prefixes to the words in general use, the terms *hyper* or *per* and *hypo*. Still these amendments have not obviated the difficulty, as will be seen by reference to the combinations of oxygen with sulphur. This conflict of terms was not, however, the greatest evil. The *ic* and *ous* terminals are worse than useless for expressing the degrees of oxidation, because the same terminal has a different signification in almost every series of oxides. Similar objection may be made to the use of the terminal *a* in the names of oxides; for example, Soda, now Na_2O; Magnesia, **MgO**; Alumina, Al_2O_3; and Silica, formerly SiO_3, by many now written SiO_2. Early in the present century, the words *protoxide*, *deutoxide*, etc., were used to distinguish the several degrees of oxidation having the simple ratio of combining proportions, i. e., 1 : 2, 1 : 3, 1 : 4. No more complex ratios than 2 : 3 were provided for. Many of these, and similar names applied to electro-negative elements, are often misused by distinguished authors who have adopted the atomic notation; for instance, *sesqui* to designate the combination of six atoms of a halogen with two atoms of carbon, or two of a biatomic metal.

The comparatively recent discovery of a great number of organic compounds, so called, required the coinage of many new names to designate radicals. Simultaneously the attempt was first made by German chemists to state definitely by prefixes the number of "equivalents" of each element in combination, which has resulted in the formation of names of a frightful length, scarcely pronounceable and seldom remembered. A complete catalogue of the chemical bodies now known would embrace several thousand terms. The novice, misled at

first by common and commercial names, like "milk of lime," "sugar of lead," "cream of tartar," "oil of vitriol," and "butter of antimony," but who had advanced far enough to find no sulphur in sulphuric ether, no copper in copperas, no lead in black lead, no soda in soda water, and to be assured that "Dutch liquid" is not imported from Holland, might look with interest and wonder on the accumulated names approved by the highest authorities, and inquire whether this magnificent patchwork could be of much service as a chemical chart. To a negative reply, should be added, "Yet a substitute for the whole has been provided by the Notation."

The introduction of chemical symbols by Berzelius marks an era of progress quite as plainly as the first employment of Arabic signs and numerals in the mathematics. The notation is now frequently employed to the exclusion of chemical names, in oral as well as written communications. Its general adoption forty years ago, with the atomic signification originally attached to it by Berzelius, would have prevented the confusion of terms and signs now consequent upon the conformation of the atomic volume of gaseous elements to the one standard. Berzelius barred certain letters, to signify that one half the combining weight was the atomic weight; in other words, that the so-called "equivalent" contained two atoms. Gerhardt, on the other hand, used the same mark to denote that the combining weight must be doubled to express the atomic weight. Miller, in the third edition of his "Elements of Chemistry," designates the old notation in the usual way, and the new notation by italic capitals; while Watts, in his "Dictionary of Chemistry," still in process of publication, just reverses Miller's arrangement.

The following symbols, representing a molecule of water according to three different views, will explain what induced Berzelius, who measured volume and atomic weight on the oxygen scale, to halve the symbols representing the combining proportion of hydrogen; and why Gerhardt, who simplified measurements by making the hydrogen atom the unit of weight and bulk, was led to double the value of the symbol for oxygen, without knowing to how many other symbols the doubling process would finally be applied.

Dalton.	Berzelius.	Gerhardt.
(2 vol.) H O (1 vol.)	1 vol. H, 1 vol. H } O 1 vol.	1 vol. H, 1 vol. H **O** 1 vol. $= H_2 O^2$
$1 + 8 = 9.$	$.5 + .5 + 8 = 9.$	$1 + 1 + 16 = 18.$

No inconsistency arises in the interpretation of these symbols; and although grave objections have been made by Herschel and Odling to the mingling of mathematical and chemical signs in chemical equations, it must be admitted that the symbol of a compound universally denotes the real body, which may be clothed with synonymes more or less expanded to suit the peculiar views of different schools.

Quite a serious derangement of the nomenclature has followed the introduction of the atomic notation. A majority of the old names have thus become inappropriate; and, chiefly for this reason, many well-known European chemists, and nearly all American chemists, still prefer to use the old system expressing combining proportions. No sweeping innovation which changes or perverts the meaning of old terms, rendering old and familiar works on chemistry comparatively worthless, and which tends to eradicate fundamental ideas, will be accepted by the present generation. How utterly futile would be the unanimous resolve of a World's Convention to change the value of our common numerals so as to represent a unit by the figure 2. Yet if they should propose to leave the old signs undisturbed, and to use new characters having the same numerical value with other important significations, the project could, perhaps, be carried into practical operation. Thus in any science it will be found most feasible to designate new views, or new structures, by new and appropriate names. This subject has commanded the attention of all advanced chemists. At the meetings of the London Chemical Society, the question has been discussed by Graham, Williamson, Miller, Brodie, Frankland, Odling, Hoffman, and other distinguished members. Gmelin's names, as modified by Watts and his compeers, seem to be received with most favor. Williamson, Foster, and Williams have suggested valuable alterations. One would, however, be safe in predicting that, while the *ic* and *ous* system predominates, the root of the perplexity will not be reached.

The nomenclature now presented is the result of an attempt to obviate the continual embarrassment attending the prosecution of chemical studies. Failing to remember the exact composition of certain compounds, the writer resorted to mnemonical methods; and, after repeated trials, devised, in the year 1845, a system of words, generally unlike any found in dictionaries, which, with certain modifications, he has constantly employed since that time. It was originally adapted to the old classification of acids, basis, and salts, but was so arranged as

to be most conveniently used in defining combinations of hydrogen, or a metal with a radical, according to the binary system. It was also early employed in explaining the now discarded Nucleus theory, as advocated by Lœwig in 1851.

Although the importance of the Typical system of classification was clearly set forth by Hunt in 1848 (*Amer. Journ. Science*, V. 265; VI. 173), not until after memorable experiments and discoveries by European chemists had demonstrated its great value, was the decision made to modify this nomenclature so as to be used with facility in expressing the new views. In attempting to take this step, however, another serious obstacle was encountered in the diversity of opinion regarding atomic weights. Kopp and Regnault had thrown new light on the subject; yet chemists of the Unitary school still agreed with the views originally advanced by Gerhardt, and recognized many metals, besides silver and those of the alkaline class, as monatomic. In 1861, however, Gibbs made it manifest that if the atomic weights of carbon, oxygen, and sulphur be taken respectively at 12, 16, and 32, the received numbers of, at least, fifty elements must be doubled (*Amer. Journ. Science*, XXXI. 246). More recently, prompted by Canizzaro, the disciples of Gerhardt have almost unanimously renounced such opinions on comparative atomic weights as are at variance with those of Berzelius.

The meaning of the new notation having thus been definitely fixed, while the nomenclature may be said to be still in the transition state, an atomic system of names, intended to supply the place *both of the notation and the old nomenclature*, is submitted for candid and critical examination. A leading consideration has been to produce a system which will assist the student in acquiring and retaining a knowledge of fundamental laws; also to provide such brief technical terms as will enable chemists generally to express their views with more conciseness.

Doubtless the most rapid advance has been made by students who have daily witnessed the operations of the laboratory. No oral description of chemical experiments could make so deep and permanent an impression. This principle of retention was well appreciated and expressed by Horace: —

> "Segnius irritant animos demissa per aurem,
> Quam quæ sunt oculis subjecta fidelibus."

Next in importance to experimental knowledge must be ranked a system of words and symbols which will convey, at sight, by means of their combinations, a clear idea of the union of the elements, without denoting, in every instance, by rational formulæ, the manner of such union. The ear, also, should be brought into service in such a system, by making the very sound of the symbols so excite the power of association as to bring before "the mind's eye" the whole series of similar and nearly related compounds. To accomplish these objects, it was necessary to construct an entirely new scheme, by providing for every well-investigated chemical body a name which should at once designate the kind and number of atoms composing it, and to a certain extent its typical and functional characteristics. This work was accomplished in a true conservative spirit, by building the new structure from old materials and upon a foundation which is the result of the combined labors of those truly great men who have devoted their lives to the advancement of chemical science.

The method of construction will be briefly explained under the following heads: —

1. The system is based on abbreviations of the universally received names of the metals, and on the chemical symbols of the metalloids, or non-metallic elements, with such modifications as were imperatively required.

2. The name of each chemical element relates, not to its mass, but only to a minimum combining proportion termed an atom, or to some multiple of it. The atom is, therefore, the unit of measurement, and the starting-point of the scale in each series of compounds.

3. The atomic name of each metal consists of two syllables, and ends with the consonant *m*.

4. The name of each of the thirteen metalloids terminates with a different consonant. Arsenic and tellurium, classed by French chemists among the metalloids, have, in this arrangement, the terminal letter common to the metals.

5. The number of atoms of any element is designated by the vowel immediately preceding its terminal consonant. The numerical power of the vowels advances with the order in which they are placed in the alphabet. *One, two, three, four,* and *five* are respectively expressed by *a, e, i, o,* and *u,* having the short or stopped sound as heard in *bat, bet, bit, hot, hut;* and *six, seven, eight, nine,* and *ten* by the same vowels having a long or full sound. In foreign languages, it may be best to

designate the long sound by a sign placed *over* the vowel; but in our language it is found by experience more convenient to place *e before* each of the vowels, which invariably indicates their long or full sound, as heard in the words *great, greet, sleight, yeoman, euphony.* These ten distinctive sounds may be illustrated by a single example. From one to ten atoms of iron, inclusive, have the following names: —

Fe, Ferram; Fe_2, Ferrem; Fe_3, Ferrim; Fe_4, Ferrom; Fe_5, Ferrum; Fe_6, Ferream; Fe_7, Ferreem; Fe_8, Ferreim; Fe_9, Ferreom; Fe_{10}, Ferreum.

The proper diphthongs are sometimes used for the even numbers between 10 and 20. These will be remembered from the fact that their value is the sum of their vowel-values, either short or long: thus, *oi* is $12 = 9 + 3$; *ou* is $14 = 9 + 5$; *au* is $16 = 6 + 10$; *oo* is $18 = 9 + 9$. The consonant *y* is 10, and used only in connection with vowels, which will express all the numbers to and including 20; *w* is 20, and, with the usual appendage, will express the numbers to and including 30. *X* is also used, and when *preceded* by a vowel, which thus has the power of an exponent, will express a progression by tens to one hundred; thus, 10, *ax;* 20, *ex;* 30, *ix;* 40, *ox;* 50, *ux;* 60, *eax;* 70, *eex;* 80, *eix;* 90, *eox;* 100, *eux.* In the same manner, these vowels preceding *qu* express the hundreds to and including one thousand, and the intermediate numbers are represented by suffixing some of the characters previously explained.

Very few chemical compounds, now known, have a composition represented by atomic numbers higher than one hundred. A large majority of the bodies of known composition do not require numbers as high as ten. The following selections will show more clearly the numerical value of each letter, and the extent to which this numerative system may be carried.

a, 1	*ea*, 6	*aa*, 11	*y*, 10	*w*, 20	*ax*, 10	*aqu*, 100
e, 2	*ee*, 7	*oi*, 12	*ya*, 11	*wi*, 23	*ex*, 20	*equ*, 200
i, 3	*ei*, 8	*ou*, 14	*yi*, 13	*wee*, 27	*ix*, 30	*eiqu*, 800
o, 4	*eo*, 9	*au*, 16	*yeo*, 19	*weo*, 29	*eix*, 80	*eoquix*, 930
u, 5	*eu*, 10	*oo*, 18	*yeu*, 20	*weu*, 30	*eux*, 100	*euqueix*, 1080

6. The following metalloids have names terminating with their well-known symbolic letters: one atom of each is here denoted.

Fluorine,	*fluraf* or *af;*	Bromine,	*bromab* or *ab;*
Nitrogen,	*nitran* or *an;*	Phosphorus,	*phosap* or *ap;*
Carbon,	*carbac* or *ac;*	Sulphur,	*sulphas* or *as.*

In a few instances where the symbolic letter could not be used, the

terminal letter adopted may be associated with some prominent characteristic of the element. Thus *l* represents the *lightest* of substances, an atom of hydrogen is *hydral* or *al;* *d* represents the *densest* of the gaseous elements, an atom of chlorine is *chlorad* or *ad;* *v* represents a *volatile* producing a *violet* vapor, one atom of iodine is *iduv* or *av*. The atom *par excellence* is *at:* oxygen, exceeding in quantity all other elements of the earth's crust, has for the name of a single atom *oxat* or *at*. An atom of selenium is *selaz* or *az:* it bears a strong resemblance in its reactions to *as*. Boron and silicon, or silicium, like carbon, are permanent solids when isolated; their terminals may be remembered by the association of *j* and *k* in the alphabet; an atom of boron is *boraj*, or *aj*, an atom of silicon is *silak* or *ak*.

The compounds of carbon and hydrogen are so numerous that it has been found essential to provide an additional character to represent each. The letter *r* may be associated with the radiating and refracting power of carbon; and *carbar*, or *ar*, as well as *ac*, will represent an atom of carbon. As *ac* might be mistaken for *ak*, in radical compounds, the carbon component is denoted generally by *r*.

The only case in which it has been found advantageous to use one letter to designate two atoms is that of *h* for two atoms of hydrogen or *hydrel*, thus preserving the ratio of the old combining numbers, $C_2H_2O_2$ being *cht*. It will be noted that *ach* corresponds with C_2H_2 in the old notation, and with CH_2 in the new: it is the key to a series of radicals, i. e., methyl, CH_3 is *achal;* ethyl, C_2H_5 *echal*.

7. Metalloid terminal syllables express as much as the full name, and are used as suffixes to names of metallic atoms to denote a metallic compound; for example, the protoxide of iron is *ferramat*, which indicates very clearly that one atom of iron is united with one atom of oxygen. A combination of metalloid syllables represents a non-metallic compound. In numerous cases, the number of syllables forming such a word is less than the number of different elements in the compound, because two or more terminal characters may be united, and the vowel or diphthong preceding the whole will be applicable to each; for instance, *elt* $= H_2O_2$ is a molecule of oxygenated water, or peroxide of hydrogen; *arn* $= CN$ is an atom of cyanogen, and *ant* $= NO$ is a molecule of binoxide of nitrogen. It will be seen presently that the names of salts containing one atom of a metal are sometimes slightly abbreviated by omitting the *a* which should precede *m;* also

that *m*, with a vowel preceding it, is applied to multiples of any radical playing the part of a metal.

The following table embraces all the chemical elements known with certainty, and their atomic numbers corresponding with the systems of Berzelius and Gerhardt, to each of which the new names are equally applicable. The highest and lowest known oxides of each element are also added. Names included in brackets are hydrates containing three elements. In twelve cases, where the same metal is known by two names, each name has been adapted to the new system; the first name in each couplet is derived from that recognized by chemists of every nation.

Symbols.	At. wt. al.=5.	At. wt. al.=1.	Name of one atom.	Name of a molecule (2 at)	Name of lowest oxide.	Name of highest oxide.
H	.5	1.	Hydral	Hydrel	H_2O *Hydrelat*	H_2O_2 *Hydrelt*
N	7.	14.	Nitran	Nitren	N_2O *Nitrenat*	N_2O_5 *Nitrenut*
O	8.	16.	Oxat	Oxet		
C	6.	12.	Carbac	Carbec		
"	"	"	Carbar	Carber	CO *Carbart*	CO_2 *Carbaret*
Si	14.	28.	Silak	Silek		SiO_2 *Silaket*
B	5.45	10.9	Boraj	Borej		B_2O_3 *Borejit*
P	15.5	31.	Phosap	Phosep	PO *Phosapt*	P_2O_5 *Phosepnt*
S	16.	32.	Sulphas	Sulphes	SO_2 *Sulphaset*	SO_3 *Sulphasit*
Se	39.75	79.5	Selaz	Selez	SeO_2 *Selazet*	(*Alazot*)
F	9.5	19.	Fluraf	Fluref		
Cl	17.73	35.46	Chlorad	Chlored	Cl_2O *Chloredat*	(*Aladot*)
Br	40.	80.	Bromab	Bromeb		(*Alabit*)
I	63.5	127.	Idav	Idev	HIO (*Alavat*)	I_2O_7 *Idevet*
Metals.						
Cs	66.5	133.	Cœsam	Cœsem	Cs_2O *Cæsemat*	(*Cæsamalt*)
Rb	42.5	85.	Rubam	Rubem	*Rubemat*	(*Rubamalt*)
K	19.5	39.	Kalam, *or*	Kalem	*Kalemat*	(*Kalamalt*)
"	"	"	Potam	Potem	*Potemat*	(*Potamalt*)
Na	11.5	23.	Natam, *or*	Natem	*Natemat*	(*Natamalt*)
"	"	"	Sodam	Sodem	*Sodemat*	(*Sodamalt*)
L	3.5	7.	Litham	Lithem	*Lithemat*	(*Lithamalt*)
Ba	68.5	137.	Baram	Barem	BaO *Baramat*	*Baramet*
Sr	43.8	87.6	Stronam	Stronem	*Stronamat*	*Stronamet*
Ca	20.	40.	Calcam	Calcem	*Calcamat*	
Mg	12.15	24.3	Magam	Magem	*Magamat*	
Al	13.7	27.4	Alam	Alem	*Alemit*	
G	4.7	9.4	Glucam	Glucem	*Glucemit*	
Zr	44.75	89.5	Ziram	Zirem	*Zirenit*	
Th	119.	238.	Thoram	Thorem	*Thoramat*	
Yt	30.85	61.7	Yttram	Yttrem	*Yttramat*	
E	56.30	112.6	Erbam	Erbem	*Erbamat*	
Tb			Terbam	Terbem	*Terbamat ?*	
Ce	46.	92.	Ceram	Cerem	*Ceramat*	*Ceremet*
La	46.47	92.94	Lanam	Lanem	*Lanamat*	
Di	48.	96.	Didam	Didem	*Didamat*	
Zn	32.75	62.5	Zinam	Zinem	*Zinamat*	(*Zinamelt*)
In	35.91	71.82	Indam	Indem	*Indamat*	

TABLE. — (*Continued.*)

Symbols.	At. wt. al. = 5.	At. wt. al. = 1.	Name of one atom.	Name of molecule (2 at)	Name of lowest oxide.	Name of highest oxide.
Cd	56.	112.	Cadam	Cadem	*Cadamat*	
Co	29.50	59.	Cobam	Cobem	*Cobamat*	*Cobemit*
Ni	29 87	58.74	Nikam	Nikem	*Nikamat*	*Nikemit*
U	60.	120.	Uram	Urem	*Uramat*	*Uremit*
Fe	28.	56.	Ferram, *or*	Ferrem	*Ferramat*	*Ferremit*
"	"	"	Iram	Irem	*Iramat*	*Iremit*
Cr	26.27	52.54	Chram	Chrem	(*Chramalt*)	*Chramit*
Mn	27.50	55.	Manam	Manem	*Manamat*	*Manamet*
Sn	59.	118.	Stanam *or*	Stanem	*Stanamat*	*Stanamet*
"	"	"	Tinam	Tinem	*Tinamat*	*Tinamet*
Ti	25	50.	Titam	Titem	*Titamat*	*Titamet*
Nb	49.13	98.26	Nobam *or*	Nobem	*Nobemit*	*Nobamet*
Cl	"	"	Colam	Colem	*Colemit*	*Colamet*
Ta	91. ?	182. ?	Tanam	Tanem	*Tanemit*	*Tunamet*
Mo	48.	96.	Molam	Molem	*Molamat*	*Molamit*
V	68.46	136.92	Vanam	Vanem	*Vanamat*	*Vanemit*
W	92.	184.	Walam	Wolem	*Wolamat*	*Wolamit*
"	"	"	Tunam	Tunem	*Tunamat*	*Tunamit*
As	37.5	75.	Arsam	Arsem	*Arsamat*	*Arsamit*
Sb	60.15	120.3	Stibam *or*	Stibem	*Stibamat*	*Stibamit*
"	"	"	Antam	Antem	*Antamat*	*Antamit*
Bi	105.	210.	Bisam	Bisem	*Bisamat*	*Bisamet*
Cu	31.75	62.5	Cupam *or*	Cupem	C_2O *Cupemat*	*Cupamet*
"	"	"	Coppam	Coppem	*Coppemat*	*Coppamet*
Pb	103.5	207.	Plubam *or*	Plubem	*Plubemat*	*Plubamet*
"	"	"	Leadam	Leadem	*Leadamat*	*Leadamet*
Tl	101.75	203.5	Thallam	Thallem		*Thallamit*
Te	64.5	129.	Tellam	Tellem	*Tellamat*	*Tellamit*
Hg	100.	200.	Hygam *or*	Hygem	*Hygemat*	*Hygamat*
"	"	"	Mercam	Mercem	*Mercemat*	*Mercamat*
Ag	54.	108.	Argam *or*	Argem	*Argemat*	*Argamet*
"	"	"	Silvam	Silvem	*Silvemat*	*Silvamet*
Au	98.33	196.66	Auram *or*	Aurem	*Auremat*	*Auremit*
"	"	"	Goldam	Goldem	*Goldemat*	*Goldemit*
Pt	98.56	199.12	Platam	Platem	*Platamat*	*Platamet*
Pd	53.24	106.48	Pallam	Pallem	*Pallemat*	*Pallamet*
Ro	52.16	104.32	Rhodam	Rhodem	*Rhodamat*	*Rhodemit*
Ru	52 11	104.22	Rutham	Ruthem	*Ruthamat*	*Ruthamet*
Os	99.41	198.82	Osman	Osmen	*Osmamat*	*Osmamot*
Ir	98.56	197.12	Irdam	Irdem	*Irdamat*	*Irdamet*

As a whole, the old symbols, representing combining proportions, are applicable to neither column of atomic weights. Fewer changes are required by adopting the weights of the first column; yet the advantages derived from estimating H = 1 are so obvious, that the symbols used in the remainder of the paper will represent the numbers in the second column. Those having the old value will be denoted by the usual letters, and symbols of doubled value by full-faced type.

A complete series of known oxides of several metals (excluding

hydrates) are here presented, for the purpose of comparing the old and new system as to brevity and precision.

1. Protoxide of iron (Ferrous oxide),	FeO:	*Ferramat.*
Sesquioxide or Peroxide of iron (Ferric oxide),	Fe_2O_3:	*Ferremit.*
Intermediate oxides.		
Black or Magnetic oxide of iron (Ferroso-ferric oxide),	Fe_3O_4:	*Ferrimot.*
A nameless oxide of iron (auct. Berthier & Glasson), $4\ FeO\ Fe_2O = Fe_6O_7$:		*Ferreameet.*
Scale oxide of iron (inner layer), $6\ Fe\ O\ Fe_2O_3 = Fe_8O_9$:		*Ferreimeot.*

The name of the latter, expressing the supposed rational formula, is *Ferreameat-Ferremit.*

2. Protoxide of manganese (Manganous oxide),	MnO:	*Manamat.*
Red oxide of manganese (Manganoso-manganic oxide),	Mn_3O_4:	*Manimot.*
Sesquioxide of manganese (Manganic oxide),	Mn_2O_3:	*Manemit.*
Peroxide of manganese (Dioxide of M.),	MnO_2:	*Manamet.*

3. The Chromium atom, properly *Chromam*, may be contracted to *Chram*; which is especially convenient in denoting chromates.

Protoxide of Chromium (Chromous oxide),	CrO:	*Chramat.*
Magnetic oxide of chrome (Chromoso-chromic oxide),	Cr_3O_4:	*Chrimot.*
Sesquioxide of chromium (Chromic oxide),	Cr_2O_2:	*Chremit.*
Monochromate of sesquioxide of chromium,	Cr_3O_6:	*Chrimeat.*
Bichromate of sesquioxide of chromium,	Cr_4O_9:	*Chromeot.*
Neutral chromate of sesquioxide of chromium,	$Cr_5\ O_{12}$:	*Chrumoit.*
Acid chromate of sesquioxide of chromium,	Cr_6O_{15}:	*Chreamyut.*
Chromic acid.	CrO_3	*Chramit.*

Including hydrates, the oxides of metals, metalloids, and organic radicals now known may be estimated in round numbers at 400. The following oxides of a halogen are adduced to show the inadequacy of the old nomenclature in defining the higher combining ratios of only two elements: —

Iodic anhydride, I_2O_5, *evut*; Hypoiodic acid, I_2O_4, *evot*; Intermediate oxide (auct. Kæmmerer), I_6O_{13}, *eavyit*; Subhypoiodic acid (auct. Millon), $I_{10}O_{19}$, *euryeot*.

A few brief observations will perhaps aid in apprehending the purport of numerous new combinations, illustrating the doctrine of types and substitutions.

1. An atom has a definite maximum power of holding other atoms in chemical union. The normal quantivalence or highest saturating capacity of an atom, that is, its so-called atomicity, decreases as it is duplicated and condensed.

2. *Chlorad* is ranked in the class of elements having the lowest saturating power: therefore *ad* may be taken as the unit of measurement, and thus words already in use in this connection are made peculiarly appropriate; for example, *hydral* is a monad, *oxat* is a dyad *nitran* is a triad (often a pentad), *carbar* is a tetrad, *phosap* is a pentad and often a triad. *Carber, ferrem, alem, chromem,* and other DOUBLE-ATOMS forming sesquioxides, behave like hexads, while *manam* appears to be a heptad. *Arsam, bisam,* and *stibam* are either triads or pentads.

3. A molecule is a complete chemical structure, capable of existing in a separate state: that part of it which can unite with various monad radicals — known as the residue or remainder of a molecule — being regarded as a broken structure or imperfect body may be called a *torso.*

4. The atomicity of a torso, or of a radical containing one atom of an element united to one or more atoms of another element, is equal to the difference between the normal saturating power of its components. The following are examples: —

COMPOUND MONADS: Ammonium, H_4N''' = *olan* or *ilanal'*; Hydroxyl, $H'O''$ = *alt'*; Amidogen, H_2N'' = *elan'*; Nitric oxide, $N'''O_2''$ = *anet'*; Cyanogen, $C^{iv}N'''$ = *arn'*.

COMPOUND DYADS: Carbonyl (Carbonic oxide), $C^{iv}O''$ = *arat* or *art''*; Monamine, HN''' = *alan''*; Methylene, $C^{iv}H_2$ = *arel* or *ach''*.

COMPOUND TRIADS: Formene, $C^{iv}H$ = *arl'''*; Phospil, $P^{v}O''$ = *apt'''*.

5. The researches of Kekulé have shown that the same number of carbon and hydrogen atoms, having different saturating powers, are related to different hydrocarbon series; and the equivalence of such isomers may be determined by the number of hydrogen atoms they contain. For example, glyceryl, C_3H_5 (*echarl'''*), having three less hydrogen atoms than the hydride of propyl (*ichel*), C_3H_8, is a triad; while allyl, C_3H_5 (*arechal'*), having one atom of hydrogen less than propylene, C_3H_6 (*irlil''*), is a monad. Thus also to the series of highest saturation of carbon belongs acetylene, C_2H_2 (*erel* or *erl*^{iv}); and having four atoms of hydrogen less than the hydride of ethyl, C_2H_6 (*echel*), it is a tetrad. If two atoms of the monad bromine be added, the saturating power of the compound will be diminished two degrees; therefore the bibromide of acetylene, $C_2H_2Br_2$ (*erleb*) is a dyad. The

late brilliant elucidations of atomicity by Wurtz have thrown light on many points, to which reference cannot now be made.

6. A complex hydrocarbon monad radical may be regarded as the combination of a monad with an even number of radicals or torsoes *in equilibrio*. The following are examples : —

Acetyl = $(\mathbf{CO}''\mathbf{CH}_2'') + \mathrm{H}$ = *artachal'*.
Propyl = $(\mathrm{CH}_2''\mathrm{CH}_2'') + \mathrm{CH}_3'$ = *ichal'*.
Butyl = $(\mathrm{CH}_2''\mathrm{CH}_2''\mathrm{CH}_2''\mathrm{CH}_2'') + \mathrm{H}$ = *ochal'*.

7. Gerhardt classified chemical compounds under four types, two of which, the hydrogen and the hydrochloric-acid types, are molecules consisting of two monads : one molecule should therefore be taken as the primal type, and the other as a sub-type. The use of only three types would, at first sight, be commended for its simplicity ; yet the vast diversity of Nature's combinations involves the necessity of many multiples, and the formation of mixed types as proposed by Odling, in which the saturating power of the several parts is distinguished by the signs used in this paper. Valid arguments may be urged in favor of using at least five types, in each of which one-half the saturating power expended to form the molecule is derived from a single atom. The atom-holding power of one-half being balanced by that of the other half of each molecule, it is proposed to distinguish each type by the name expressing the equivalence of one-half of it. The following will show the value of the new characters in typical expressions : —

Monad type.	Dyad type.	Triad type.	Tetrad type.	Pentad type.
Hydrochloric acid.	Water.	Ammonia.	Marsh gas.	Chloride of phosphorus.
al } *ad.*	*al* } *at.*	*al* } *an.*	*al* } *ar.*	*al* } *ap.*

In representing the most important bodies formed by the replacement of one or more atoms of hydrogen by one or more monad radicals, the change consists, as will presently be shown, simply in substituting for *al* the name of a radical ending with *al*. The different views of chemists respecting the typical form of the same body may be distinctly illustrated by the new characters ; take, for example, acetic acid, $\mathrm{C_4H_4O_4} = \mathbf{C_2H_4O_2}$. Kolbe's carbonic-acid type, being essentially the same as the water type, is omitted, and the so-called radical type is added in the following table : —

Empirical.	Gerhardt.	Debs.	Frankland & Duppa.
olert or *echet.*	*al* } *artachal* } *at.*	*ar* { *achal'* *at''* *alt'.*	*ar* { *al* *al* *al* } *at''* *alt'.*

The empirical name *echet* is the second in a series of which *achet* (formic acid) is the first; *ichet* (propylic acid), the third; *ochet* (butylic acid), the fourth; *uchet* (amylic acid), the fifth; and so on to the highest or most condensed molecule *weuchet* (melissic acid), represented in the old notation by HO $C_{60}H_{59}O_3$, and in the new by $\mathbf{C_{30}H_{60}O_2}$. These short and simple names, formed by changes in the first syllable, represent these acids as the result of successive additions of *ach* ($\mathbf{CH_2}$); but they cannot be made available in illustrating the changes which occur when an atom of hydrogen is replaced by a metal or a radical. The other empirical name may be used by those who prefer to express no opinion as to the actual constitution of the acid. To carry out this view, the replaceable atom of hydrogen in the acid may form the first syllable, and the remaining syllables will be the terminal of the acetates formed by monad metals, e. g., acetic acid, *alilert;* acetate of potash, *Kalmilert.* The terminal syllables must be doubled in value, to denote acetates of dyad metals; for example, acetate of lead, *Plabmealort.* In consideration of the existence of numerous important bodies, into the construction of which an acid-forming radical of this series enters, it has been found most desirable to designate the acids by names which bring the radical more clearly to view. Preference is therefore given to those which are readily resolved into the water or dyad type; thus, acetic acid, as *alartachalt* or *lartachalt,* is easily separated into syllables which reveal its typical structure [*al-artachal*]*at.* When *al* is replaced by a monad metal, the typical form is still apparent [*am-artachal*]*at.* An atom of a dyad metal replaces the hydrogen atom in two molecules of acid: therefore the torso *artachalt* is doubled, which is indicated by the suffix *e* having the sound of *eh,* thus, *artachalte.* In the sesquiacetates, the double-torso *artachalte* is trebled, and indicated by the suffix *ea* = 6; for example, one of the acetates of alumina = $\mathbf{Al^2C_{12}H_{18}O_{12}}$, is *Alem-artachaltea.*

All the types previously enumerated may be regarded as subtypes, embraced in a regular series of types consisting of condensed mole-

cules of hydrogen, according to the suggestion originally made by Hunt. In the following table, containing several new types, the condensed hydrogen molecules are connected with the types of substantially the same significance by the mathematical symbol of equivalency. Atoms in brackets in the first series are replaced by other atoms in the second.

Ratios.	Hydrogen molecules.	Old names.	New names.
1 : 1 al-[al]	$\eqsim$ HCl,	Hydrochloric acid	= *alad.*
2 : 1 el-[el]	$\eqsim$ H_2O,	Water	= *elat.*
3 : 1 il-[il]	$\eqsim$ H_3N,	Ammonia	= *ilan.*
1 : 4 [ol]-ol	$\eqsim$ CH_4,	Marsh gas	= *arol.*
1 : 5 [ul]-ul	$\eqsim$ PCl_5,	Pentachloride of phosphorus	= *apud.*
1 : 6 [eal]-eal	$\eqsim$ CrF_6,	Perfluoride of chromium	= *chrameaf.*
1 : 7 [eel]-eel	$\eqsim$ $MnCl_7$,	Perchloride of manganese	= *manameed.*
1 : 4 [ol]-ol	$\eqsim$ CH_3H,	Hydride of methyl (*achal-al*)	= *achel.*
II : 6 [eal]-eal	$\eqsim$ $C_2^{\prime}H_5^{\prime}H$,	Hydride of ethyl (*echal-al*)	= *echel.*
III : 8 [eil]-eil	$\eqsim$ C_3H_7H,	Hydride of propyl (*ichal-al*)	= *ichel.*
IV : 10 [eul]-eul	$\eqsim$ C_4H_9H,	Hydride of butyl (*ochal-al*)	= *ochel.*
V : 12 [yel]-yel	$\eqsim$ $C_5H_{11}H$,	Hydride of amyl (*uchal-al*)	= *uchel.*
VI : 14 [yol]-yol	$\eqsim$ $C_6H_{13}H$,	Hydride of caproyl (*eachal-al*)	= *eachel.*
VII : 16 [yeal]-yeal	$\eqsim$ $C_7H_{15}H$,	Hydride of œnanthyl (*eechal-al*)	= *eechel.*
VIII : 18 [yeil]-yeil	$\eqsim$ $C_8H_{17}H$,	Hydride of capryl (*eichal-al*)	= *eichel.*
XII : 26 [weal]-weal	$\eqsim$ $C_{12}H_{25}H$,	Hydride of lauryl (*oichal-al*)	= *oichel.*
XVI : 34 [ixol]-ixol	$\eqsim$ $C_{16}H_{33}H$,	Hydride of cetyl (*auchal-al*)	= *auchel.*
XXVII: 56 [uxeal]-uxeal	$\eqsim$ $C_{27}H_{55}H$,	Hydride of ceryl (*weechal-al*)	= *weechel.*
XXX : 62 [eaxel]-eaxel	$\eqsim$ $C_{30}H_{61}H$,	Hydride of melissyl (*weuchal-al*)	= *weuchel.*

It is evident that the so-called "atomicity" does not prevent the union of atoms in a regular progressive series of ratios. In such cases the atom-holding energy has different degrees of development as the result of the reflex influence of combination. Apparent abnormal action, for instance, in the case of I_2O_7, *ereet*, may be accounted for by supposing an even number of atoms of oxygen, O_6, in alternately opposite polar conditions, to be united with I_2O. When mercury and chlorine form calomel, *mercamad*, the anomaly is explained by the fact that the volume of the compound corresponds with that of a molecule of hydrogen; thus, in this, as well as the case of the hydride of copper, *cupamal*, a dyad metal plays the part of a monad.

The new names of acids and salts, of simple as well as intricate constructions, are so framed that they may readily be resolved into syllables expressing their typical relations. This is accomplished by

making the replaceable hydrogen of an acid the prefix which determines the type on which the compound is constructed, as explained previously in speaking of the acetic acid. The typical name of an acid or salt embraces, in fact, three terms; the first consists of the replaceable hydrogen, the second is another portion of the compound of equal equivalence to the first, and the remaining oxygen atoms will constitute a third term having the atomic equivalence of the first and second terms combined. In chemical reactions, the second and third terms generally remain unchanged, and may therefore be included as one name, and the whole name may be said to represent the combination of a radical with a torso. Examples: —

Nitric acid,	"monatomic"	[al′-anet′]at′′	= *alanit.*
Sulphuric acid,	"biatomic"	[el′′-aset′′]etiv	= *elasot.*
Phosphoric acid,	"triatomic"	[il′′′-apt′′′]itvi	= *ilapot.*

The halogens are powerful electro-negative elements. Having the best structural adaptability, as monads, they are found among the components of many bodies. Those well investigated may be estimated in round numbers thus: Chlorides, 750; iodides, 320; fluorides, 160; bromides, 150; to which may be added another class of very similar structure: the cyanides, 220; total, 1630. In this estimate, several hundred chlorhydrates, bromhydrates and iodhydrates are not included. Their new names will be so readily understood, it is only essential to present such examples as will explain the changes required by the atomic notation and the typical classification: —

MONAD TYPE.

Hydrofluoric acid,	HF,	*alaf:*	Fluoride of thallium,	*Thalamaf.*
Hydrochloric acid,	HCl,	*alad:*	Chloride of sodium,	*Sodamad.*
Hydrobromic acid,	HBr,	*alab:*	Bromide of ammonium,	*Olanab.*
Hydriodic acid,	HI,	*alav:*	Iodide of potassium,	*Potamav.*
Hydrocyanic acid,	HCy,	*alarn:*	Cyanide of silver.	*Argamarn.*

DYAD TYPE.

Fluor spar,	*Calcamef.*	Corrosive sublimate,	*Mercamed.*
Chloride of thorium,	*Thoramed.*	Bromide of cadmium,	*Cadameb.*
Bromide of yttrium,	*Yttrameb.*	Iodide of zinc,	*Zinamev.*
Cyanide of iron,	*Ferramern.*	Cyanide of magnesium,	*Magamern.*

TRIAD TYPE.

Fluoride of arsenic,	*Arsamif.*	Chloride of antimony,	*Stibamid.*
Bromide of gold,	*Auramib.*	Iodide of bismuth,	*Bisamiv.*
Bromide of nitrogen,	*Anib.*	Solid chloride of cyanogen,	*Irnid.*
Fluoride of boron,	*Ajif.*	Bromide of boron,	*Ajib.*

TETRAD TYPE.

Perfluoride of titanium,	*Titamof.*	Perchloride of tin,	*Stannamod.*
Perbromide of tellurium,	*Tellamob.*	Periodide of platinum,	*Platamov.*
Perchloride of tantalium,	*Tanamod.*	Percyanide of palladium,	*Pallamorn.*

PENTAD TYPE.

Pentachloride of antimony,	*Stibamud.*	Quinquiodide of arsenic ?	*Arsamuv.*
Pentabromide of phosphorus,	*apud.*	Quinquebromide of iodine,	*avub.*

Quinquiodide of tetrethyl-ammonium, *echalom-anuv.*

HEXAD TYPE.

Perfluoride of vanadium,	*Vanameaf.*	Periodide of tellurium,	*Tellameav.*
Perchloride of molybdenum,	*Molamead.*	Perfluoride of chromium,	*Chrameaf.*
Perbromide of tungsten,	*Wolameab.*	Perfluoride of silicon,	*Akeaf.*
Perfluoride of selenium,	*Azeaf.*	Perbromide of silicon,	*Akeab.*

SUBTYPE, OR RADICAL TYPE.

Chloride of aluminium,	*Alemead.*	Perchloride of iron,	*Ferremead.*
Perchloride of cerium,	*Ceremead.*	Perfluoride of ruthenium,	*Ruthemeaf.*
Perfluoride of glucinum,	*Glucemeaf.*	Chloride of osmium,	*Osemead.*

HEPTAD TYPE.

Perchloride of manganese, *Manameed.* | Perfluoride of manganese, *Manameef.*

The sulphides, selenides, and tellurides resemble in constitution the oxides. From nearly 300 well-known sulphides, the following are selected : —

Sulphuretted hydrogen,	*elas.*	Persulphide of hydrogen,	*elus.*
Bisulphide of carbon,	*ares.*	Bisulphide of nitrogen,	*enes.*

Monosulphide of potassium (old name) KS = K_2S. *Kalemas.*
Monosulphide of mercury (cinnabar). *Meremas* or *Hygamas.*
Bisulphide of iron (pyrites), *Ferrames.*
Tersulphide of gold, *Auramis.*
Quadrisulphide of molybdenum, *Molamos.*
Pentasulphide of antimony, *Antamus* or *Stibamus.*
Sesquisulphide of rhodium, *Rhodemis.*
A magnetic iron pyrites (with no systematic name), Fe_3S_4, *Ferrimos.*
Another variety of pyrites, Fe_7S_8 (no name), *Ferreemeis.*

The next table contains the known combinations of oxygen with sulphur, forming oxides and acids : —

Sulphurous anhydride,	*aset.*	Hyposulphurous acid,	*elesit.*
Sulphurous acid,	*elasit.*	Hyposulphuric acid,	*eleseat.*
Sulphuric anhydride,	*asit.*	Trithionic acid,	*eliseat.*
Nordhausen sulphuric acid,	*aleseat.*	Tetrathionic acid,	*eloseat.*
Sulphuric acid (oil of vitriol),	*elasot.*	Pentathionic acid,	*eluseat.*
Trithionic anhydride,	*isut.*		

In these acids or salts of hydrogen, *el* may be replaced by a dyad metal, or, atom for atom, by a monad metal, thus forming metallic salts.

From nearly 700 known varieties of sulphates, the following are selected: —

Sulphate of protoxide of iron,	*fermasot.*	Sulphate of copper,	*cupmasot.*
Sulphate of magnesia,	*magmasot.*	Sulphate of baryta,	*barmasot.*
Sulphate of soda,	*natemasot.*	Sulphate of lithium,	*lithemasot.*

Of nearly 200 sulphites, only two will be mentioned: —

Sulphate of cerium,	*cermasit.*	Sulphite of potash,	*kalemasit.*

From nearly 200 carbonates, only the following are selected: —

Carbonate of lime,	*calcmarit.*	Carbonate of magnesia,	*magmarit.*
Carbonate of soda,	*natemarit.*	Bicarbonate of soda,	*natmalarit.*

Of 300 oxalates, only two are here cited: —

Oxalate of baryta,	*barmerot.*	Salt of sorrel,	*potmalerot.*

From 100 varieties of silicates, only the following will be noted: —

Silicate of alumina (sillimanite), Al_2SO_5, *alemakit.*
Silicate of alumina (kaolin), $Al_2S_2O_7$, *alemekeet.*
Silicate of potash, *potemakit.* Silicate of lime, *calcmakit.*
Silicate of magnesia, *magmakit.*

From about 50 nitrites, only two are presented: —

Nitrite of soda,	*sodmanet.*	Nitrite of strontia,	*stronmenot.*

From 400 varieties of nitrates, the following are selected: —

Nitrate of potash, *kalmanit.* Nitrate of silver, *argmanit.*
Nitrate of uranium, *urmeneat.* Protonitrate of iron, *fermeneat.*
Nitrate of sesquioxide of iron, $Fe_2O_3\ N_6O_{15}$, *ferremeanoot.*

Of 370 phosphates, only the following: —

Tribasicphosphate of lime (in bones), $Ca_3P_2O_8$, *calcimepeit.*
Bibasic phosphate of lime, $Ca_2HP_2O_8$, *calcemalepeit.*
Acid or Superphosphate of lime, $CaH_4P_2O_8$, *calcmolepeit.*

From 90 sulphocyanides, only one will be mentioned: —

Sulphocyanide of mercury, $HyCy_2S$, *mercmernas.*

A few other terminals of salts may be thus briefly enumerated, a monad metal being denoted by *am* : —

210 tartrates,	*em-orleat.*	40 chlorates have the terminal	*amadit.*
60 malates,	*em-orlut.*	60 iodates have the terminal	*amavib.*
100 citrates,	*im-earuleet.*	330 chlorhydrates have the prefix	*ald.*
120 chromates,	*em-chramot.*	50 bromhydrates have the prefix	*alb.*
270 chloroplatinates,	*am-platamid.*	100 iodhydrates have the prefix	*alv.*

Ferro-cyanhydrates or -cyanides, *em-ferramirn.*

Ferri-cyanhydrates or -cyanides, *im-ferremearn.*

The monad radicals forming the largest class of alcohols, and the corresponding monad radicals of the fatty-acid series, are in the next table placed side by side : —

Alcohol-forming radicals.		Acid-forming radicals.	
Methyl,	$CH_3 = CH_2H$, *achal.*	Formyl,	COH, *artal.*
Ethyl,	$C_2H_5 = C_2H_4H$, *echal.*	Acetyl,	$COCH_3$, *artachal.*
Propyl,	$C_3H_7 = C_3H_6H$, *ichal.*	Propionyl,	COC_2H_5, *artechal.*
Butyl,	$C_4H_9 = C_4H_8H$, *ochal.*	Butyryl,	COC_3H_7, *artichal.*
Amyl,	$C_5H_{11} = C_5H_{10}H$, *uchal.*	Valeryl,	COC_4H_9, *artochal.*
Caproyl,	$C_6H_{13} = C_6H_{12}H$, *eachal.*	Caproylyl,	COC_5H_{11}, *artuchal.*
Œnanthyl,	$C_7H_{15} = C_7H_{14}H$, *eechal.*	Œnanthoyl,	COC_6H_{13}, *arteachal.*
Capryl,	$C_8H_{17} = C_8H_{16}H$, *eichal.*	Caprylyl,	COC_7H_{15}, *arteechal.*
	Wanting.	Pelargonyl,	COC_8H_{17}, *arteichal.*
	"	Rutilyl,	COC_9H_{19}, *arteochal.*
	"	Enodilyl,	$COC_{10}H_{21}$, *arteuchal.*
Lauryl,	$C_{12}H_{25} = C_{12}H_{24}H$, *yechal.*	Laurilyl,	$COC_{11}H_{23}$, *artaxachal.*
	Wanting.	Coccinyl,	$COC_{12}A_{25}$, *artaxechal.*
	"	Meristyl,	$COC_{13}H_{27}$, *artaxichal.*
	"	Benyl,	$COC_{14}H_{29}$, *artaxochal.*
Cetyl,	$C_{16}H_{33} = C_{16}H_{32}H$, *yeachal.*	Palmityl,	$COC_{15}H_{31}$, *artaxuchal.*
	Wanting.	Margaryl,	$COC_{16}H_{33}$, *artaxeachal.*
	"	Stearyl,	$COC_{17}H_{35}$, *artaxeechal.*
	"	Balenyl,	$COC_{18}H_{37}$, *artaxeichal.*
	"	Arachidyl,	$COC_{19}H_{39}$, *artaxeochal.*
	"	Nardyl,	$COC_{20}H_{41}$, *artaxeuchal.*
Ceryl,	$C_{27}H_{55} = C_{27}H_{54}H$, *weechal.*	Cerotyl,	$COC_{26}H_{53}$, *artexeachal.*
Melissyl,	$C_{30}H_{61} = C_{30}H_{60}H$, *weuchal.*	Melissilyl,	$COC_{29}H_{59}$, *artexeuchal.*

In the acid-forming series, the presence of *art″* makes the sum of the increments of *ach″* one less than in the corresponding alcohol-forming radical.

An alcohol formed on the dyad type, like water, contains one monad radical, and the corresponding ether two. Two examples of each will suffice to show the manner of illustrating by the new characters their typical form : —

ALCOHOLS.

Hydrate of methyl or Wood spirit,	*Achal al*	*at = Achclat.*
Hydrate of ethyl or Common alcohol,	*Echal al*	*at = Echclat.*

ETHERS.

Methylic oxide or Methylic ether,	*Achal Achal*	*at = Achalemat.*
Ethylic oxide or Ethylic ether,	*Echal Echal*	*at = Echalemat.*

The sulphydrates and sulphides of such radicals have structures similar to these alcohols and ethers. The following table of names shows the compound containing oxygen, and the corresponding compound containing sulphur : —

	Alcohols.	Mercaptans.	Ethers.	Sulphides.
1 Methylic	*Achelat.*	*Achelas.*	*Achalemat.*	*Achalemas.*
2. Ethylic	*Echelat.*	*Echelas.*	*Echalemat.*	*Echalemas.*
3. Propylic	*Ichelat.*	*Ichelas.*	*Ichalemat.*	*Ichalemas.*
4. Butylic	*Ochelat.*	*Ochelas.*	*Ochalemat.*	*Ochalemas.*
5. Amylic	*Uchelat.*	*Uchelas.*	*Uchalemat.*	*Uchalemas.*
6. Caproylic	*Eachelat.*	*Eachelas.*	*Eachalemat.*	*Eachalemas.*
7. Œnanthylic	*Eechelat.*	*Eechelas.*	*Eechalemat.*	*Eechalemas.*
8. Caprylic	*Eichelat.*	*Eichelas.*	*Eichalemat.*	*Eichalemas.*

As a specimen of the new names of more than 500 compounds containing an alcohol-forming radical, a few combinations with the most important, Ethyl (*echal*), are presented : —

Fluoride of ethyl,	*echalf.*	Chloride of ethyl,	*echald.*
Bromide of ethyl,	*echalb.*	Iodide of ethyl,	*echalv.*
Cyanide of ethyl,	*echalarn.*	Hydride of ethyl,	*echel.*

Acetate of ethyl,	C_2H_5-$COCH_3$-O_2,	*echal-artachalt.*
Monethylic oxalate,	C_2H_5-H-$C_2O_2O_2$,	*echelerot.*
Diethylic oxalate,	$(C\ H_5)_2$-$C_2O_2O_2$,	*cchalemerot.*
Methyl-ethylic ether,	$CH_3 + C_2H_5$-O,	*achal-echalt.*
Methyl-amylic ether,	$CH_3 + C_5H_{11}O$,	*achal-uchalt.*
Ethyl-butylic ether,	$C_2H_5 + C_4H_9O$,	*echal-ochalt.*
Ethyl-amylic ether,	$C_2H_5 + C_5H_{11}O$,	*echal-uchalt.*

Acid-forming radicals form anhydrides, corresponding in structure with simple ethers ; and hydrates (acids) corresponding with alcohols. Examples of the names of acids of this class are here given : for the first term *al, l* is used to shorten the word.

Formic acid,	H-COH-O,	*Lartalt* = *achet.*
Acetic acid,	H-COCH$_3$-O,	*Lartachalt* = *echet.*
Propionic acid,	H-COC$_2$H$_5$-O,	*Lartechalt* = *ichet.*
Butyric acid,	H-CO(C$_3$H$_7$-O,	*Lartichalt* = *ochet.*
Valeric acid,	H-COC$_4$H$_9$-O,	*Lartochalt* = *uchet.*
Caproic acid,	H-COC$_5$H$_{11}$-O,	*Lartuchalt* = *eachet.*
Œnanthylic acid,	H-COC$_6$H$_{13}$-O,	*Larteachalt* = *eechet.*
Caprylic acid,	H-COC$_7$H$_{15}$-O,	*Larteechalt* = *eichet.*
Pelargonic acid,	H-COC$_8$H$_{17}$-O,	*Larteichalt* = *eochet.*
Rutilic acid,	H-COC$_9$H$_{19}$-O,	*Larteochalt* = *euchet.*

Other combinations containing an acid-forming radical, which have been or may yet be formed, are illustrated by the names of compounds containing *artachal* (acetyl).

Chloride of acetyl,	*artachald.*	Bromide of acetyl,	*artachalb.*
Aldehyde,	*artachel.*	Acetic anhydride,	*artachalemat.*
Sulphydrate of acetyl,	*lartachals.*	Sulphide of acetyl,	*artachalemas.*
Hydrate of chloracetyl,	*lartachadat.*	Hydrate of bromacetyl,	*lartachabat.*
Hydride of tribromacetyl,	*artacibel.*	Chloride of trichloracetyl,	*artacod.*

Twenty-two other radicals, similar to *artachal*, may form hundreds of compounds by uniting with electro-negative elements.

Acetones or Ketones, composed of an acid-forming radical and an alcohol-forming radical, have the constitution of the monad type. Of the fifteen bodies now known, seven are here cited: —

Methyl-acetyl (Acetone),	CH$_3$,C$_2$H$_3$O,	*achal-artachal.*
Methyl-butyryl,	CH$_3$,C$_4$H$_7$O,	*achal-artichal.*
Methyl-valyl,	CH$_3$C$_5$H$_9$O,	*achal-artochal.*
Ethyl-propionyl (Propione),	C$_2$H$_5$,C$_3$H$_5$O,	*echal-artechal.*
Ethyl-butyryl,	C$_2$H$_5$,C$_4$H$_7$O,	*echal-artichal.*
Propyl-butyryl (Butyrone),	C$_3$H$_7$,C$_4$H$_7$O,	*ichal-artichal.*
Butyl-valyl (Valerone),	C$_4$H$_9$,C$_5$H$_9$O,	*ochal-artochal.*

In the following hydrocarbon homologous series, formed by multiples of *ach* and known as the olefiant-gas series, one atom of carbon saturates but two atoms of hydrogen, the equivalence being thus expressed : *or* =○= *el.* These bodies are dyads, each taking the place of two atoms of hydrogen in the water type.

Methylene (not yet isolated),	CH$_2$,	*arlal.*	Ethylene or Olefiant gas,	C$_2$H$_4$,	*erlel.*
Propylene,	C$_3$H$_6$,	*irlil.*	Butylene (Oil gas),	C$_4$H$_8$,	*orlol.*
Amylene,	C$_5$H$_{10}$,	*urlul.*	Caproylene,	C$_6$H$_{12}$,	*earleal.*
Œnanthylene,	C$_7$H$_{14}$,	*eerleel.*	Caprylene,	C$_8$H$_{16}$,	*eirliel.*
Elaene,	C$_9$H$_{18}$,	*eorleol.*	Paramylene,	C$_{10}$H$_{20}$,	*eurleul.*

This series unite with dyads, and also with two atoms of a monad, of which the annexed are specimens: —

Oxide of ethylene	or Glycolic ether,	*erlelat* or *echat.*
Oxide of propylene	or Propyl-glycolic ether,	*irlilat* or *ichat.*
Oxide of butylene	or Butyl-glycolic ether,	*orlolat* or *ochat.*
Oxide of amylene	or Amyl-glycolic ether,	*urlulat* or *uchat.*
Hydrate of ethylene	or Ethylic-glycol,	*erlelelt* or *echelt.*
Hydrate of propylene	or Propylic glycol,	*irlilelt* or *ichelt.*
Hydrate of butylene	or Butylic glycol,	*orlolelt* or *ochelt.*
Hydrate of amylene	or Amylic glycol,	*urlulelt* or *uchelt.*

The hydrate of glyceryl, $[C_3H_5\text{-}H_3]O_3$ = *echarlilt*, is a triad alcohol. If *il*, the second term, is replaced by three atoms of the monad *anet* = *ineat*, the interesting explosive compound Nitroglycerine is formed, the three terms of the type being [*echarl-ineat*] *it* = *echarlineot*. On the other hand, if *il* in *echarlilt* be replaced by three atoms of the monad-acid radical $COC_{17}H_{35}$, *artaxeechal*, the compound known as Tristearin is formed, containing . . . . . $C_{57}H_{110}O_6$ = *uxuchereat*. In like manner, only two or one atom of hydrogen may be replaced by two or one atom of the acid-radical.

Artificial fats may have been formed by the action of acids on glycerin, *echarlilt*; and the following from among the glycerides are presented, with their new empirical names: —

Monacetin,	$C_5H_{10}O_4$,	*uchot.*	Monolein,	$C_{21}H_{40}O_4$,	*axeucharot.*
Monobutyrin,	$C_7H_{14}O_4$,	*eechot.*	Monopalmitin,	$C_{19}H_{38}O_4$,	*axeechot.*
Monovalerin,	$C_8H_{16}O_2$,	*eichot.*	Monostearin,	$C_{21}H_{42}O_2$,	*exachot.*

That modification of sugar known as glucose or starch sugar, $C_6H_{12}O_6$, has lately been regarded by some chemists as a hexatomic or hexad alcohol. According to this view, its new name is *earlealt*. There are about thirty varieties of sugars and gums of nearly the same composition, to which new names should not be given until there is a general agreement among chemists as to their composition and constitution.

Artificial alkaloids, or compound ammonias of Wurtz and Hoffman, formed on the triad or ammonia type [*al-ul-al*]*an*, in which an atom of hydrogen is replaced by a radical, are thus illustrated: —

Methylamine.	Ethylamine.	Amylamine.	Phenylamine. (Aniline.)
achal)	*echat*)	*uchal*)	*carolal*)
al ⌐ *an*,	*al* ⌐ *an*,	*al* ⌐	*al* ⌐
al)	*al*)	*al*)	*al*)
achilan.	*echilan.*	*uchilan.*	*carolilan* or *carelan.*

Dimethylamine.	Diethylamine.	Diamylamine.	Diphenylamine.
achal }	*echal* }	*uchal* }	*earolal* }
achal } *an*,	*echal* } *an*,	*al* } *an*,	*earolal* } *an*,
al }	*al* }	*al* }	*al* }
achalemalan.	*echlemalan.*	*uchalemalan.*	*earulemalan.*

Trimethylamine.	Triethylamine.	Tryamylamine.	Triphenylamine.
achal }	*echal* }	*uchal* }	*earolal* }
achal } *an*,	*echal* } *an*,	*uchal* } *an*,	*earolal* } *an*,
achal }	*echal* }	*uchal* }	*earolal* }
achaliman.	*echaliman.*	*uchaliman.*	*earuliman.*

Three different radicals may be found in the same compound. To denote this, requires names somewhat longer than the preceding: thus, —

Methyl-ethyl-phenylamine, $[CH_3\text{-}C_2H_5\text{-}C_6H_5]N$, is *achal-echal-earulan.*
Diethyl-chloro-phenylamine, $[(C_2H_5)_2C_6H_4Cl]N$, is *echalem-earoladan.*

Other triad elements form similar compounds. From the tertiary derivations are selected the following two : —

Bromide of bromethyl-triethyl-phosphonium = *echeb-echalimap.*
Bromide of ethylene-hexethyl-diphosphonium = *echeb-echaleamep.*

Some of the denser molecules of hydrocarbons are here presented : —

Cetylene	$= C_{16}H_{32}$, *yeach.*	Melissylic alcohol	$= C_{30}H_{62}O$, *weuchelat.*
Cetylic alcohol	$= C_{16}H_{34}O$, *yeachelat.*	Spermaceti (pure)	$= C_{32}H_{64}O_2$ *ixechet.*
Cerene (paraffin)	$= C_{27}H_{56}$, *weech.*	Myricin	$= C_{46}H_{92}O_2$, *oxeachet.*
Cerylic alcohol	$= C_{27}H_{26}O$, *weechelat.*	Chinese wax	$= C_{54}H_{108}O_2$, *uxochet.*
Melene (paraffin)	$= C_{30}H_{60}$, *weuch.*		

Combinations of metals with alcohol-forming radicals, or metallic derivatives of alcohols : —

Kakodyl (auct. Bunsen),	$As(CH_3)_2$,	*Arsmereal* or *achalem-arsam.*
Arsenio-monomethyl (auct. Baeyer),	$AsCH_3$,	*Arsmaril* or *achal-arsam.*
Arsenio-trimethyl,	$As(CH_3)_3$,	*Arsmirael* or *achalalim-arsam.*
Arsenio-tetramethyl,	$As(CH_3)_4$,	*Arsmoroil* or *achalom-arsam.*
Quadrichloride of arsenio-monomethyl,	$AsCH_3Cl_5$,	*Arsmarilod* or *achal-arsamod.*
Triethyl-bismuthene,	(C_2H_5) Bi,	*echalim-bisam.*
Trimethyl-stibio,	$(CH_3)_3$ Sb,	*Stibmeheol* or *achalim-stibam.*
Stibio-tetramethylium,	$(CH_3)_4$ Sb,	*achalom-stibam.*
Chloride of stibio-tetramethylium,	$(CH_3)_4$ SbCl,	*achalom-stibmad.*
Oxide of stibio-tetramethylium,	$(CH_3)_8$ SbO,	*achaleim-stibamet.*
Nitrate of stibio-tetramethylium,	$(CH_3)_4$ SbNO_3,	*achalom-stibmanit.*
Neutral Sulphate of stibio-tetramethylium,		*achaleim-stibemasot.*

Zinc-dimethyl,	$(CH_3)^2Zn$,	*Zinmereal* or *achalem-zinam.*
Zinc-diethyl,	$(C_2H_5)^2Zn$,	*echalem-zinam.*
Zinc-diamyl,	$(C_5H_{11})^2Zn$,	*uchalem-zinam.*
Cadmium-diethyl,	$(C_2H_5)^2Cd$,	*echalem-cadam.*
Magnesium-diethyl,	$(C_2H_5)^2Mg$,	*echalem-magam.*
Stannic ethide,	$(C_2H_5)^4Sn$,	*echalom-stannam.*
Plumbo-tetrethyl,	$(C_2H_5)^4Pb$,	*echalom-plubam.*
Hydrargo-dimethyl,	$(CH_3)^2Hg$,	*achalem-hygam.*

From the products of destructive distillation, the following homologous series is selected, which must be recognized principally by the first syllable denoting the amount of carbon; for by substitutions and combinations, the hydrogen of these bodies may all be displaced, and numerous compounds formed which are indicated by terms having no part of the original name except that defining the carbon.

Benzol or Benzene, or Hydride of phenyl, $C_6H_4H_2$				*earl* or *carolel.*	
Toluol,	$C_7H_6H_2$,	*eerealel.*	Xylol,	$C_8H_8H_2$,	*eirlel.*
Cumol,	$C_9H_{10}H_2$,	*eoreulel.*	Cymol,	$C_{10}H_{12}H_2$,	*euroilel.*

Compounds related to the first body only of this series will be noted: —

The Hydride of phenyl, C_6H_6, *earolel*, is formed on the monad type.
Chloride of phenyl or Monochloride of benzene, is *earolald;* and
Bromide of phenyl or Monobromide of benzene, is *earolalb.*
The Hydrate of phenyl, better known as Carbolic or Phenic acid, sometimes called Phenic alcohol and Phenol, has the empirical name of *earlat.* As an alcohol, its new name would be *earolelat;* as an acid, *learolalt.* Its relation with aniline will be recognized by the empirical name of aniline (as well as of picodine), *eareelan*, the typical name being *earolilan;* or if the radical is expressed in two syllables, *earulelan*, i. e. Monophylamine; thus Triphenylamine is expressed by *earuliman.*

In the following table are embraced the known dyad homologues of the carbonic-acid and oxalic-acid series, formed by the increment *ach:* —

Carbonic acid (hypothetical hydrate),	H_2CO_3,	*el-arit.*
Glycolic acid,	$C_2H_4O_3 = H_2CH_2CO_3$,	*el-acharit.*
Lactic acid,	$C_3H_6O_3 = H_2C_2H_4CO_3$,	*el-echarit.*
Butilactic acid,	$C_4H_8O_3 = H_2C_3H_6CO_3$,	*el-icharit.*
Phocic acid,	$C_6H_{10}O_3 = H_2C_4H_8CO_3$,	*el-acharit.*
Leucic acid,	$C_6H_{12}O_3 = H_2C_5H_{10}CO_3$,	*el-acharit.*

Oxalic acid,	$H_2C_2O_4$,	*el-erot.*
Malonic acid,	$C_3H_4C_4 = H_2\,CH_2\,C_2O_4$,	*el-acherot.*
Succinic acid,	$C_4H_6O_4 = H_2\,C_2H_4\,C_2O_4$,	*el-echerot.*
Pyrotartaric acid,	$C_5H_8O_4 = H_2\,C_3H_6\,C_2O_4$,	*el-icherot.*
Adiptic acid,	$C_6H_{10}O_4 = H_2\,C_4H_8\,C_2O_4$,	*el-ocherot.*
Pimelic acid,	$C_7H_{12}O_4 = H_2\,C_5H_{10}\,C_2O_4$,	*el-ucherot.*
Suberic acid,	$C_8H_{14}O_4 = H_2\,C_6H_{12}\,C_2O_4$,	*el-eacherot.*
Anchoic acid,	$C_9H_{16}O_4 = H_2\,C_7H_{14}\,C_2O_4$,	*el-eecherot.*
Sebacic acid,	$C_{10}H_{18}O_4 = H_2\,C_8H_{16}\,C_2O_4$,	*el-eicherot.*

The substitution of a dyad metal, or two atoms of a monad metal, for *el* in this series, will form the corresponding metallic salts.

In a similar manner may be classified alkaloids; for instance, those obtained by dry distillation of animal matter: —

Pyridine,	C_5H_5N,	*urlan.*
Picoline,	$C_6H_7N = CH_2C_5\,H_5N$,	*achurlan.*
Lutidine,	$C_7H_9N = (CH_2)^2\,C_5H_5N$,	*cchurlan.*
Collidine,	$C_8H_{11}N = (CH_2)^3\,C_5H_5N$,	*ichurlan.*
Pavoline,	$C_9H_{13}N = (CH_2)^4\,C_5H_5N$,	*ochurlan.*

Substitutions. Dumas' doctrine of substitutions is very clearly set forth in the following examples: —

1. Marsh gas = *arol.* Chloride of methyl *(achald)* = *arilad.*
   Monochlorinated chloride of methyl, *areled.*
   Dichlorinated chloride of methyl (chloroform), *arlid.*
   Perchlorinated chloride of methyl, *arod.*

2. Ethylene, *erle.* Chlorinated ethylene, *erlald.*
   Dichlorinated ethylene, $C_2H_2Cl_2$, *erled.*
   Trichlorinated ethylene, C_2HCl_3, *eralid.*
   Perchlorinated ethylene, C_2Cl_4, *erod.*

3. The action of chlorine on ethylene and chloride of ethyl produces metameric compounds having widely different boiling points, thus distinguished: —

Dichloride of ethylene (Dutch liquid),	$C_2H_3\,HCl_2$,	= *erleld.*
Monochlorinated chloride of ethyl,	$C_2H_4\,ClCl$,	= *eched.*
Monochlorinated dichloride of ethylene,	$C_2H_3\,ClCl_2$,	= *erlalid.*
Dichlorinated chloride of ethyl,	$C_2H_3\,Cl_3$,	= *ecilid.*
Dichlorinated dichloride of ethylene,	$C_2H_2\,Cl_2Cl_2$	= *erlod.*
Trichlorinated chloride of ethyl,	$C_2H_2\,Cl_4$,	= *eclod.*
Trichlorinated dichloride of ethylene,	$C_2H\,Cl_2Cl_3$	= *eralud.*
Tetrachlorinated chloride of ethyl,	$C_2\,H\,Cl_5$,	= *ecalud.*
Perchlorinated dichloride of ethylene,	$C\,Cl_4Cl_2$,	= *eread.*
Perchlorinated chloride of ethyl,	$C_2\,Cl_6$, (identical)	*eread.*

4. Naphthalene, $C_{10}H_8$, *eureil.* (Paranaphthaline, $C_{14}H_{10}$, *yoreul.*)

Chloronaphthaline,	*eureelad.*	Bromonaphthaline,	*eureelab.*
Dichloronaphthaline,	*eureeled.*	Dibromonaphthaline,	*eureeleb.*
Trichloronaphthaline,	*eurulid.*	Tribromonaphthaline,	*eurulib.*
Tetrachloronaphthaline,	*eurold.*	Tetrabromonaphthaline,	*eurolb.*
Hexachloronaphthalene,	*eureleed.*	Perchloronaphthaline,	*eureid.*

5. Chlorides and Bromides of Naphthaline, with Gmelin's names and formulæ: —

Hydrochlorate of chloronaphthaline,	$C_{10}H_7Cl$ HCl	= *eureiled.*
Hydrochlorate of chlorobromonaphthaline,	$C_{10}H_6BrCl$ HCl	= *eureelabed.*
Hydrobromate of quadribromonaphthaline,	$C_{10}H_4Br_4$ HBr	= *eurulb.*
Bihydrochlorate of bichloronaphthaline,	$C_{10}H_6Cl_2$ 2 HCl	= *eureilod.*
Bihydrochlorate of bromochloronaphthaline,	$C_{10}H_6BrCl$ 2 HCl	= *eureilabid.*
Bihydrochlorate of terchloronaphthaline,	$C_{10}H_5Cl_3$ 2 HCl	= *eureelud.*
Bihydrochlorate of quadrichloronaphthaline,	$C_{10}H_4Cl_4$ 2 HCl	= *eureald.*
Bihydrochlorate of bibromobichloronaphthaline,	$C_{10}H_4Br_2Cl_2$ 2 HCl	= *eurealebod.*
Bihydrobromate of bibromobichloronaphthaline,	$C_{10}H_4Br_2Cl_2$ 2 HBr	= *eurealedob.*
Bihydrobromate of terbromochloronaphthaline,	$C_{10}H_4Br_3Cl$ 2 HBr	= *eurealadub.*
Bihydrobromate of quadribromonaphthaline,	$C_{10}H_4Br_4$ 2 HBr	= *eurealb.*
Bihydrochlorate of bibromoterchloronaphthaline,	$C_{10}H_3Br_2Cl_3$ 2 HCl	= *eurulebod.*
Bihydrobromate of pentabromonaphthaline,	$C_{10}H_3Br_5$ 2 HBr	= *eurulecb.*

Isomerism. By applying the principle of permutation in the arrangement of letters, the same name is never given to metameric bodies having the same ultimate composition. A few examples will sufficiently prove the adaptation of the new system to cases of isomerism. Each of the following ten bodies has the empirical formula $C_{10}H_{20}O_2$: —

Rutic or Capric acid,	$H\,CO\,C_9H_{18}O$,	*Larteochalt.*
Formiate of clayl,	$C_9H_{19}\,CO\,HO$,	*eochal-artalt.*
Acetate of capryl,	$C_8H_{17}\,CO\,CH_3O$,	*eichal-artachalt.*
Propionate of œnanthyl,	$C_7H_{15}\,CO\,C_2H_5O$,	*eechal-artechalt.*
Butyrate of caproyl,	$C_6H_{13}\,CO\,C_3H_7O$,	*cachal-artichalt.*
Valerate of amyl,	$C_5H_{11}\,CO\,C_4H_9O$,	*uchal-artochalt.*
Caproate of butyl,	$C_4H_9\,CO\,C_5H_{11}O$,	*ochal-artuchalt.*
Œnanthate of propyl,	$C_3H_4\,CO\,C_6H_{13}O$,	*ichal-arteachalt.*
Caprylate of ethyl,	$C_2H_5\,CO\,C_7H_{15}O$,	*echal-arteechalt.*
Pelargonate of methyl,	$CH_3\,CO\,C_8H_{17}O$,	*achal-arteichalt.*

Each of the seven following compound ammonias has the same ultimate composition, $C_6H_{15}N$: —

Triethylamine,	$(C_2H_5)^3$ N,	*echaliman.*
Dipropylamine,	$(C_3H_7)^2$ H N,	*ichalemalan.*
Caproylamine,	C_6H_{13} H_2N,	*eachilan.*
Amyl-methylamine,	C_5H_{11} CH_3HN,	*uchal-achelan.*
Butyl-dimethylamine,	C_4H_9 $(CH_3)^2$ N,	*ochal-achaleman.*
Butyl-ethylamine,	C_4H_9 C_2H_5 HN,	*ochal-echelan.*
Propl-ethyl-methylamine,	C_3H_7 C_2H_5 CH_3N,	*ichal-echal-achalan.*

Two Ammonia-cobalt metamers, empirical formula (H_3N) CCl_3, are here cited: —

Roseo-pentammonia-cobaltic chloride,	*ilanum-cobamid.*
Purpureo-pentammonia-cobaltic chloride,	*yulun cobamid.*

It has already been admitted that the improved names, as found in Watts' New Dictionary, have the merit of more precision than the old nomenclature in designating the proportions of non-metallic elements; but this precision is not always observed in that portion of the name defining the metal. For the purpose of comparison, a few of the names given as examples under the article on Nomenclature, page 125, are here inserted, with the symbols and the proposed new names: —

Platinic dichloride	= $PbCl_2$,	*Platamed.*
Diplumbic trioxide	= Pb_2O_3,	*Plubemit.*
Triplumbic tetroxide	= Pb_3O_4,	*Plubimot.*
Diplumbo-dihydric trioxide	= $[Pb_2H_2]O_3$,	*Plubemelit.*
Triplumbo-dihydric tetroxide	= $[Pb_3H_2]O_4$,	*Plubimelot.*
Bismuthic oxichloride	= $BiClO$,	*Bisamadat.*
Diplumbic oxidichloride	= Pb_2Cl_2O,	*Plubemedat.*
Triplumbic dioxidichloride	= $Pb_3Cl_2O_2$,	*Plubimedet.*
Trimercurio-dioxidichloride	= $Hg_3Cl_2O_2$,	*hygimedet.*
Hydrargyro-dihydric-chloronitride	= $HgCl$ H_2N,	*hygmadelan.*
Tetramercurio-tetrahydric-trioxidinitride	= H_4N_2 Hg_4O_3,	*olen-hygomit.*
Tetramercurio-tetrahydric-dioxidichlorodinitride	= $Hg_4H_4Cl_2N_2O$,	*hygom-oledent.*

Water has three distinct functions recognized in the notation, but not in the common nomenclature, which are clearly defined in the new system.

1. Water as a true chemical component: it is thus designated by *elat*, *alalt* or *lalt*. The first of these names, when forming a part of another name, may denote the typical structure and the rational formula of the compound: it may indicate, likewise, that precisely the same number and kind of atoms, by another arrangement, would form two independent and stable bodies; for instance, *echelat* denotes that

alcohol is formed by the combination of the radical *echal* with the water torso *alat* or *alt*, and is modelled after the dyad type; it also indicates the fact proved by the synthetic process of Berthelot, that alcohol contains all and precisely the components forming olefiant gas and water. The other name of water, *alalt* or *lalt*, shows more clearly how the torso *alt*, torn from *al*, will unite with a monad radical or metal and form a perfect body, like, for example, hydrate of potash, *potamalt;* hydrate of lime, *calcamelt.*

2. Water as a mechanical component of certain crystals. Under the plastic trowel of symmetry, it fills the interstices, so to speak, builds up and completes the structure. During this mysterious process of construction, the pair of hydrogen atoms are supposed to still cling to oxygen; and the molecule having such close atomic ties is distinguished by the term *allt.* This is the only case where the same consonants are found side by side: the relation in which the word is used will prevent its being confounded with the torso *alt.* By changing the vowel prefix, any number of molecules, either of water of crystallization, or of constitutional water, as Graham styles it, may be denoted. As a general rule, this name precedes the essential name of the compound; for example: —

Crystallized periodic acid, with 4 atoms of water,	*ollt-alavot.*
Crystallized oxalic acid with 2 aqua,	*ellt-elerot.*
Prismatic nitrate of copper with 3 aqua,	*illt-cupmeneat.*
Rhomboidal nitrate of copper with 6 aqua,	*eallt-cupmeneat.*
Nitrate of lime with 4 aqua,	*ollt-calcmeneat.*
Nitrate of strontia with 5 aqua,	*ullt-stronmeneat.*
Nitrate of lithia with 5 aqua,	*ullt-lithmanit.*
Protonitrate of iron with 6 aqua,	*eallt-fermeneat.*
Hyposulphite of soda with 5 aqua,	*ullt-sodemasit.*
Sulphate of soda with 10 aqua,	*eullt-sodemasot.*
Carbonate of soda with 10 aqua,	*eullt-sodemarit.*
Sulphate of alumina and potash with 24 aqua,	*wolltalem-potemosoit.*
Sulphate of alumina and thallium with 24 aqua,	*wolltalem-thallemosoit.*

3. Water as a solvent or menstruum, modifying, in proportion to its quantity, the chemical power and functions of the compound held in solution. The complete and equable diffusion of a soluble body, by which its characteristics are manifested through the medium of this fluid, may be regarded as the effect of a contiguity resulting from molecular rather than atomic attraction. In this case, the pair of hydrogen atoms are designated by the letter *h*, and the oxygen atom by

t ; and *th*, as a prefix to the name of a compound, denotes that such compound is held in solution by an indefinite quantity of water. Any amount corresponding to a definite number of molecules of water may be represented by the usual vowels placed before *th*. The following brief exhibit of names will show the economy and precision of expression applicable to substances now commonly called and recognized only by misnomers.

A solution of hydrochloric acid and water,	*thalad.*
Fuming solution containing 43 per cent. of HCl or 6 aqua,	*eathalad.*
Solution of HCl which distils unchanged (20 per cent. acid, or 16 aqua),	*authalad.*
Hydrate of chlorine $(H_2O)^5$ Cl,	*uthad.*
Sulphuric acid, distinguished as oil of vitriol,	*elasot.*
Sulphuric acid with indefinite quantity of water,	*thelasot.*
Glacial sulphuric acid,	*athelasot.*
Nitric acid, indefinite solution by water,	*thalanit.*
Nitric acid, solution containing 60 per cent NO_3 or 3 aqua,	*ithalanit.*
Solution of ammonia and water,	*thilan.*
Solution of alcohol and water,	*thechelat.*
Solution of carbonic anhydride (soda water),	*tharet.*

In the further progress of chemical investigations, increasing significance must be given to the state of dilatation of the body under examination. On passing from the solid to the liquid state, its bulk will undergo but comparatively little change. In either state, the restless particles which make up the apparently unmoved mass are still obedient to the law of cohesion, although in the liquid the league of homogeneity is not so binding as to prevent the admission of foreign matter; but when, by the irresistible power of the almost infinitesimal motions of a subtle medium, heat accelerates and amplifies the excursions of particles until they fly simultaneously beyond the dominion of a common attraction, it must be admitted that the mass thus expanded to the gaseous state — in reality a vast reservoir of molecular momentum — requires some distinctive appellation. It is therefore proposed to denote every gaseous compound, and every volatile body after it has fumed into vapor, by simply prefixing to its new name the letter *g*.

Were it desirable to show the degree of condensation of gases produced by their combination, the number of volumes included in one molecule could be indicated by the usual vowels before *g ;* but as the number of atoms now conforms to the number of volumes of gaseous

elements, in most cases, the amount of condensation can be easily estimated. At present it seems essential only to indicate that the molecule has assumed a state of gas or vapor.

The succeeding names are illustrations : —

GASES at ordinary temperatures.	
Carbonic oxide,	*gart.*
Carbonic anhydride,	*garet.*
Olefiant gas,	*gerlel.*
Oil gas,	*gorlol.*
Nitrous oxide,	*genat.*
Binoxide of nitrogen,	*gant.*
Nitrous anhydride,	*ganit.*
Sulphuretted hydrogen,	*gelas.*
Ammonia,	*gilan.*
Phosphuretted hydrogen,	*gilap.*
Arseniuretted hydrogen,	*gil-arsam.*
Antimoniuretted hydrogen,	*gil-stibam.*
Cyanogen (molecule),	*gern.*
Sulphurous anhydride,	*gaset.*
Hypochlorous anhydride,	*gedat.*
Euchlorine,	*gadadat.*
Chlorous anhydride,	*gedit.*
Hydrochloric acid gas,	*galad.*
Hydrobromic acid,	*galab.*
Hydriodic acid,	*galav.*
Oxychloride of carbon,	*garted.*
Carburetted hydrogen,	*garol.*
Hydride of ethyl,	*gechel.*
Ethylide of ethyl,	*gechalem.*
Chloride of methyl,	*gachald.*
Methylic ether,	*gachalemat.*

VAPORS at heat stated on centigrade scale.	
Chloride of ethyl	11°, *gechald.*
Bromide of methyl	13°, *gachalb.*
Oxide of ethylene	13°.5, *gechat.*
Hydrofluoric acid	16°, *galaf.*
Peroxide of nitrogen	27°, *ganet.*
Sulphuric anhydride	27°, *gasit.*
Prussic acid	33°, *galarn.*
Ethylic ether	34°, *gachalemat.*
Amylene	39°, *gurlul.*
Chloride of methylene	40°, *gached.*
Protosulphide of methyl	41°, *gachelemas.*
Iodide of methyl	42°, *gachalv.*
Nitric anhydride	45°, *ganut.*
Bisulphide of carbon	47°, *gares.*
Bromide of ethyl	47°.7, *gechalb.*
Hydrideof methyl	60°, *gachelat.*
Chloroform	61°, *garlid.*
Sulphochloride of carbon	70°, *garsed.*
Caproylene	71°, *gearleal.*
Iodide of ethyl	72°, *gechalv.*
Bichloride of carbon	78°, *garod.*
Perchloride of phosphorus	78°, *gapid.*
Absolute alcohol	78°, *gechelat.*
Dichloride of ethylene	85°, *gerleld.*
Œnanthylene	99°, *geerleel.*
Steam	100°, *gelat.*

In anticipation of an inquiry as to the feasibility of applying the new nomenclature to all known chemical bodies, it may be here observed that new names have been framed for a large majority of the compounds enumerated in Storer's Dictionary of Solubilities, as well as for many modifications described in Dana's Mineralogy; yet as these names form a lexicon of chemical compounds, they cannot properly be applied to the large class about the composition of which there is still a wide diversity of opinion, particularly to those treated of in zoöchemistry, from whose percentage-analysis no satisfactory formulæ have thus far been deduced. No objection can be made, however, to the application of new terms to those compounds now designated only

by symbols, or to new bodies not yet named; such, for example, as Loew's new combination of hydrogen with the sesquisulphide of carbon, *aleris*.

Should the proposed system be favorably received, the most effectual mode of bringing it into general use would be to add to the old name of a body the new name in italics, in lieu of the ordinary symbols which now involve the use of very small figures not always read with facility. These symbols have been aptly termed the *short-hand* of the chemist; yet in a large majority of instances, the corresponding new names contain a smaller number of syllables; for example, CO_2 is pronounced with three syllables, and *garet* with two; H_2O with three syllables, *elat* with two; HO with two, *alt* with one; $COCl_2$ with five, and *garted* with two.

Those objecting to the use of chemical equations, will observe how readily the new names may be substituted for such expressions by the following examples: —

$H_2Cl_2 + Na_2O = Na_2Cl_2 + H_2O$:
eled with *sodemat* yields *sodemed* and *elat*.

$H_2SO_4 + ZnSO = ZnSO_4 + H_2O$:
elasot with *zinamat* yields *zinmasot* and *elat*

$H_2SO_4 + Zn = ZnSO_2 + H_2$:
elasot with *zinam* yields *zinmasot* and *hydrel*.

$CaN_2O_6 + Na_2SO_4 = Na_2N_2O_6 + CaSO_4$:
calcmencat and *sodemasot* yield *sodemencat* and *calmasot*.

Williamson's original view of the constitution of ethers is illustrated by the following substitute for the equation explaining the reactions which produce the oxide of diethyl: —

sodam-echalt with *echalv*, yields *Sodamav* and *echalemat*.

The use of the new nomenclature in conversations on chemical subjects would correct very soon many vulgar errors, and inculcate, by mere imitation and habit, clearer views of combinations. He who knows why he calls chloroform *arlid*, knows on the instant, and knows for life, that it is composed of one of carbon, one of hydrogen and three atoms of chlorine; or when he designates laughing gas by *genat*, he announces at once several facts not indicated by the old names, nitrous oxide or protoxide of nitrogen.

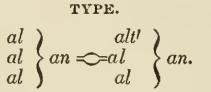
Chemical writers, who are obliged to study brevity of expression, will fully appreciate the saving of pen and type-work resulting from

the use of the new nomenclature, which may often be as marked as in the following announcement of a late scientific achievement in old and new phrase placed side by side: —

LOSSEN has succeeded in replacing [an atom of hydrogen in ammonia by an atom of hydrogen and oxygen, or hydroxyl; thus forming hydroxalamine].

LOSSEN has succeeded in replacing [*a* in *ilan* by *alt*; thus forming *altelan*]

TYPE.



Very few of the best practical chemists attempt to tax the memory with the exact symbolic formulæ of many compounds whose functions and general characteristics are well known to them; yet they are aware that the application of the theory of substitutions, in the higher branches of the science, depends on a correct conception of atomic proportions. They would therefore advise the young student, whom doubt hampers quite as effectually as downright ignorance, to avail himself of the best means to master what is known, and thus prepare himself to keep abreast the general progressive movement, and to meet the practical difficulties that constantly beset the way of the discoverer.

In conclusion, it is proper to say that only such examples have been cited as seemed essential to prove the copiousness and capacity of the proposed nomenclature. A more complete elucidation and application of it is reserved for succeeding papers.

IV. PHYSICS OF THE GLOBE.

1. On the Periodicity of the Aurora Borealis. By Joseph Lovering, of Cambridge, Mass.

As this paper will appear in full in the Memoirs of the American Academy of Arts and Sciences, over two hundred pages of which were presented in sheets to the Association, only a brief abstract will be given in this place. I was incited to the study of the laws of periodicity of the aurora by the absence of any recorded appearances of this display, in this country, before the early part of the eighteenth century, a failure in the record which could not easily be explained except by a failure in the phenomenon itself, especially when it is considered that the early settlers of New England were not likely to have overlooked appearances which they could so readily associate with the religious or political events of their heaven-determined destiny. A preliminary discussion of the subject was first published in the American Almanac for 1860, and afterwards, with some modification, in the Memoirs of the American Academy, Vol. IX. p. 101. But I was soon satisfied that no satisfactory solution of a vast problem could be reached, which was built on anything less than the richest materials that could be gathered from the records of science. Much time has been expended, therefore, in preparing and printing a complete catalogue of all the auroras observed from the earliest times down to the present year, — a catalogue which comprises about ten thousand independent auroras and fifty thousand observations.

The discussion of these materials, so far as it has yet progressed, relates especially to the distribution of auroras between the different days and months of the year, and the accuracy with which this distribution may be expressed by a periodical function. The subject is considered, not only for the whole earth, but also separately for the two hemispheres, and for each place where a series of observations has continued long enough to justify a distinct discussion. The number of auroras occurring in different seasons of the year has been computed by the following formula:

$$N = A + C_1 \sin. 2\pi (t + c_1) + C_2 \sin. 4\pi (t + c_2) + C_3 \sin. 6\pi (t + c_3);$$

and the result compared with the observations. The mean probable error has been obtained by the usual rule applied to the differences between the number of observed and computed auroras. The formula just mentioned is the same as I employed in 1845 in discussing the daily

changes of temperature and magnetic declination at Cambridge, Mass.* In 1843 Eklöf published † at Helsingfors, Russia, a mathematical investigation of the yearly march of auroral phenomena, in which he employed the same periodic function as I have adopted. Copies, however, of the Scientific Transactions, in which Eklöf published his labors are very rare in this country. I only know of the single one which I had recently an opportunity to examine, in the Astor Library, of New York. As Eklöf confined his inquiry to a few places, and to small and imperfect catalogues of auroras, what I have added to his work may not, perhaps, be superfluous.

I have taken notice in my memoir of the attempts made by Mairan, Ritter, Höslin, Quetelet, Wartmann, Boué, Baumhauer, Wolf, A. de la Rive, Fritz, and Littrow, to establish relations between the periods of auroral maxima and minima and those of shooting stars, meteors, earthquakes, disturbances in the earth's magnetism, or the sun's inflamed surface, and even the larger nutation-period of the earth's axis, to say nothing of hail-storms, snow-storms, lunar halos, winds, etc.

Since the first two hundred and forty pages of my Memoir on the Periodicity of the Aurora have been printed, General Lefroy, formerly director of the magnetic observatory in Toronto, Canada, has put at my disposal his large accumulation of observations in British America; also Prof. Joseph Henry, Secretary of the Smithsonian Institution, has placed in my hands the unpublished records of meteorology made in various parts of the United States, under the auspices of this institution, in accordance with the comprehensive plan of its accomplished Secretary. With these new and rich materials, and others not specified, to which I have had access since my first catalogue was printed, I have been induced to pause in the midst of my discussion of the *secular* periodicity of the aurora, and print a supplementary catalogue. I therefore postpone any remarks on this point until the next meeting of the Association, when I hope the new catalogue will be printed, and the investigation brought to a conclusion. However, the additional observations contained in the last catalogue, embracing, as they do, but a short period of years, will have less influence upon the question of the secular periodicity of the aurora than upon its yearly march from month to month, at Toronto, Quebec, Newfoundland, etc.; for which the observations in the first catalogue were limited to a small number of years.

* Memoirs of the American Academy of Arts and Sciences. III. 44.

† Acta Soc. Sci. Fennic. etc. II. 302.

NUMBER OF AURORAS OBSERVED EACH MONTH IN THE WESTERN HEMISPHERE.

Place.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.	Total.
Newfoundland,	9	20	14	16	11	5	13	13	16	19	5	10	151
Quebec,	6	25	14	24	7	10	13	10	19	21	13	7	169
London, Canada,	7	12	12	16	6	5	10	8	10	13	3	5	107
Toronto,	21	37	34	46	35	24	31	25	33	43	34	26	389
Jakobshavn,	27	24	17	1	0	0	0	0	17	28	34	37	185
Gothaab,	61	60	50	21	0	0	0	5	53	45	71	64	430
New York State,	76	89	110	132	89	80	106	125	141	117	75	65	1205
New Haven,	63	59	72	67	62	46	72	66	97	62	86	61	813
Newberry,	23	34	28	30	6	2	3	11	32	30	10	9	218
Providence,	15	17	14	13	18	7	10	7	21	21	14	3	160
Burlington,	8	6	9	8	12	5	6	3	8	3	3	3	74
St. Martin,	6	9	7	9	9	4	14	6	14	3	2	6	89
Wilmington,	6	1	4	1	5	5	6	5	10	3	3	4	53
Worcester,	19	13	27	25	10	9	12	19	30	22	15	11	212
Salem,	9	14	18	17	15	15	30	17	21	22	12	8	198
Boston,	2	4	1	5	1	2	2	1	6	2	6	4	36
Cambridge,	19	27	37	39	21	10	29	20	45	33	17	19	316
Cambridge,	17	31	46	33	24	26	44	40	49	32	31	17	390
Aggregates,	394	482	514	503	331	255	401	381	622	519	434	359	5195

NUMBER OF AURORAS OBSERVED EACH MONTH IN THE EASTERN HEMISPHERE.

Place.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.	Total.
Prague,	6	4	4	6	6	1	2	3	4	7	3	1	47
Ratisbon,	1	3	9	9	6	7	2	4	2	8	3	0	54
Holland,	49	47	92	103	110	34	37	59	64	74	47	34	750
Copenhagen,	1	5	9	12	4	0	3	1	4	5	2	2	48
Mannheim,	18	12	33	32	13	8	12	16	28	18	16	10	216
Scandinavia,	40	30	38	11	0	0	0	4	28	49	47	41	288
Sagan,	25	14	34	40	8	2	3	8	22	39	31	14	240
Spydberg,	8	7	17	6	2	0	0	1	10	18	6	6	81
Italy,	4	9	21	5	3	4	6	7	7	12	3	7	88
Wittemberg,	8	12	13	7	3	0	2	11	8	16	5	6	91
Franeker,	20	15	41	23	16	6	8	15	30	30	13	14	231
Montmorenci,	8	13	26	18	14	6	9	11	27	20	11	5	168
Carlsruhe,	2	9	13	15	8	2	5	11	6	8	5	3	87
Paris,	4	5	12	4	20	5	6	10	15	11	12	4	108
Berlin,	21	37	55	48	39	2	10	10	22	45	29	13	331
Upsal,	85	131	152	75	7	2	4	72	126	146	109	109	1018
Brussels,	12	13	18	22	38	23	23	11	16	23	17	15	231
St. Petersburg,	70	100	179	152	42	13	15	62	145	146	83	79	1086
Stockholm,	27	34	50	56	13	0	0	19	44	39	34	25	341
Christiania,	46	61	75	60	3	0	1	35	78	65	55	55	534
Dunse,	33	20	18	18	3	0	2	14	43	34	30	23	238
Makerstoun,	22	26	28	16	6	0	0	7	16	29	23	11	184
Plymouth, Engl.,	8	7	23	12	6	1	8	8	10	15	13	9	120
Great Britain,	21	19	23	12	3	2	1	3	35	23	21	22	185
Kendall, &c.,	18	18	26	32	21	5	2	21	23	36	38	10	250
Hammerfest,	19	16	8	0	0	0	0	0	4	9	16	19	91
Abo, &c.,	66	87	99	61	9	0	2	28	98	97	74	61	682
Jena,	2	9	4	10	4	2	4	8	14	15	6	6	84
Aggregates,	644	763	1120	865	407	125	167	459	929	1037	752	604	7872

TIMES OF MAXIMA AND MINIMA ARRANGED GEOGRAPHICALLY.

Place.	Max.	Min.	Max.	Min.	Number.	Years.	Authority.
Fort Reliance,	?	?	?	?	196		Hough.
Jakobshaven,	?	?	?	?	185	1840 – 1851	Rudolph.
Gothaab,	?	?	?	?	430	1841 – 1846	Block.
Newfoundland,	Feb.	June	Oct.	?	151	1849 – 1851	Lefroy.
Quebec,	Feb.	May	Oct.	Jan.	169	1848 – 1851	Lefroy.
London, Canada,	April	June	Oct.	?	107	1848 – 1851	Lefroy.
St. Martin,	?	June	Sept. ?	Nov. ?	89	1853 – 1854	Smallwood.
Toronto,	April	June	Oct.	Jan.	389	1848 – 1851	Lefroy.
Burlington,	?	?	?	?	74	1852 – 1853	Thompson.
Newberry,	Feb.	June	Sept.	Dec.	218	1830 – 1862	Johnson.
Salem,	March ?	June	Oct. ?	Dec.	198	1786 – 1820	Holyoke.
Providence,	Feb.	June	Sept. ?	Dec.	160	1832 – 1860	Caswell.
Boston,	?	?	?	?	36	1818 – 1848	Hale.
Cambridge,	March	June	Sept.	Dec. ?	706	1742 – 1864	Lovering, &c.
Worcester,	March	June	Sept.	Dec.	212	1839 – 1862	Woodward, &c.
New Haven,	March	June	Sept.	Dec.	813	1763 – 1854	Herrick, &c.
New York State,	April	June	Sept.	Dec.	1205	1826 – 1851	Hough.
Wilmington,	?	?	?	?	53	1827 – 1833	Gibbon.

TIMES OF MAXIMA AND MINIMA ARRANGED GEOGRAPHICALLY.

Place.	Max.	Min.	Max.	Min.	Number.	Authority.	Years.
Scandinavia,	?	?	?	?	288	Lottin, &c.,	1837 – 1840
Abo, &c.,	March	June	Sept.	Dec.	682	Hallström,	1748 – 1843
Helsingfors,	March	June	Sept.	Jan.	30	Argelander,	1832 – 1837
Spydberg,	March	June ?	Oct.	?	81	Wilse,	1784 – 1787
Hammerfest,	?	?	?	?	91	Noodt,	1850 – 1861
Christiania,	March	June	Sept.	Jan.	534	Hansteen,	1837 – 1853
Stockholm,	April	June ?	Sept.	Dec.	341	Nicander,	1783 – 1792
St. Petersburg,	March	June	Oct.	Jan.	1086	Kraft, Euler, &c.,	1726 – 1861
Upsal,	March	June	Oct.	Jan.	1018	Celsius, &c.,	1716 – 1762
Dunse,	?	June	Sept.	?	238	Stevenson,	1838 – 1847
Makerstoun,	March	June ?	Oct.	Dec.	184	Broun,	1843 – 1849
Copenhagen,	April	June	Oct.	Jan,	48	Bugge,	1782 – 1788
Kendall, &c.,	April	July	Nov.	Dec.	250	Dalton,	1786 – 1793
G. Britain,	March	July	Sept.	Jan ?	185	Dalton,	1794 – 1834
Berlin,	March	June	Oct.	Dec.	331	Kirch, Beguelin,	1707 – 1789
Leyden, Utrecht, &c.,	May	June	Oct.	Dec.	750	Musschenbroek,	1716 – 1744
Franeker,	March	June	Sept. ?	Nov.	231	Van Swinden,	1771 – 1781
Jena,	?	June	Oct.	Jan.	84	Zeissing, Succow,	1770 – 1796
Mannheim,	March	June	Sept,	Dec.	216	Hemmer,	1781 – 1792
Sagan,	April	June	Oct.	Dec.	240	Preus,	1781 – 1792
Brussels,	May	Aug.	Oct.	Jan.	231	Mann, Quetelet,	1778 – 1851
Plymouth,	March	June	Oct.	Jan.	120	Huxham,	1728 – 1748
Prague,	?	June	Oct.	Dec.	47	Strnad,	1782 – 1791
Carlsruhe,	April	June	Aug. ?	Jan.	87	Eisenlohr,	1779 – 1831
Ratisbon,	April ?	July	Oct.	Dec.	54	Heinrich,	1781 – 1791
Paris,	March	June	Sept.	Dec ?	108	Cassini, Bouvard,	1784 – 1842
Montmorenci,	March	June	Sept.	Dec.	168	Cotte,	1771 – 1805
Wittemberg,	March	June	Oct.	?	91	Weidler,	1730 – 1751
Italy,	March	May	Oct.	?	88	Beccari, Zanotti,	1727 – 1751

NUMBER OF AURORAS ON EACH DAY OF THE YEAR.

Day.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1	34	29	36	33	28	12	13	14	28	38	30	30	325
2	32	35	42	42	29	14	13	18	25	39	38	36	363
3	35	34	34	36	16	12	15	17	29	45	32	31	336
4	28	33	35	38	23	11	12	19	26	37	33	35	330
5	25	24	38	30	19	14	15	8	31	37	32	34	307
6	32	34	39	37	19	13	7	17	34	35	35	34	336
7	22	36	29	40	21	15	18	9	33	38	34	41	336
8	33	27	34	30	15	9	10	10	33	44	32	37	314
9	34	36	40	38	16	12	14	11	36	39	34	27	337
10	29	37	36	36	15	15	14	20	42	31	30	37	342
11	34	41	33	36	15	8	13	18	30	28	35	25	316
12	37	35	42	44	19	13	18	19	38	38	34	33	370
13	42	30	42	34	19	12	13	16	40	33	43	40	364
14	28	32	46	41	21	13	8	26	30	39	40	35	359
15	26	36	42	40	13	11	11	17	43	36	37	41	353
16	28	42	48	35	17	12	11	20	30	36	32	34	345
17	39	38	43	32	23	11	8	26	43	35	41	41	380
18	32	44	44	36	15	8	10	16	37	35	42	42	361
19	30	36	43	35	11	9	12	25	40	40	43	38	362
20	34	36	42	37	17	8	13	21	37	39	31	37	352
21	32	35	35	28	12	7	10	32	33	36	33	29	322
22	29	43	36	23	18	8	7	32	44	41	31	36	348
23	30	40	33	24	18	4	12	24	38	42	33	29	327
24	28	37	30	30	14	9	12	22	52	38	28	26	326
25	30	26	40	19	10	9	14	25	41	33	29	27	303
26	24	40	46	19	11	10	7	26	39	35	30	33	320
27	35	42	37	25	10	9	16	27	41	43	33	25	343
28	35	38	43	16	12	12	15	25	38	36	29	35	334
29	33	7	44	19	15	10	13	35	32	40	29	30	307
30	33		45	23	16	11	8	31	41	30	24	35	297
31	28		38		14		16	32		38		35	201
Total.	971	1003	1215	956	521	321	378	658	1084	1154	1007	1048	10316

2. Remarks on Meteorological Results deduced from the New Method of Registration. By G. W. Hough, of Albany, N. Y.

(abstract.)

A definite knowledge of the laws which govern atmospheric phenomena, we believe can only be attained by the study of continuous records. Isolated observations made two or three times each day, on temperature, pressure, etc., will never give us correct views regarding the changes continually taking place, or the manner in which they are brought about. Observations of this kind have been of great value in determining some of the more general laws of climate, but we believe nearly all the results, capable of being deduced from such data, have been attained. We must therefore look for a more complete and extensive system of observation for the deduction of the special laws governing atmospheric changes.

During the past two years there has been in successful operation at the Dudley Observatory, a registering and printing barometer, invented and first employed at this institution. This instrument gives a continuous record of the changes of atmospheric pressure, and prints, with type, the height of the barometer hourly. It also records the total motion of the barometrical column, or in other words the total amount of atmospheric disturbance; a result which has never before been attained. During the past year instruments of the same kind have been in operation at the Chamber of Commerce, New York City, and at Rutger's College, and also for a short time at Dartmouth College. The comparison of the continuous records made at these places has enabled us to deduce some interesting results.

The total motion of the barometrical column, for the year 1866, was 148.6 inches, — for summer 62.1 inches, and for winter 86.5 inches, — which is equivalent to removing the whole body of the atmosphere five times every year. The greatest motion was in the month of March, the least in June; in the former case 19 inches, in the latter 7 inches. There is apparently but little difference in the amount of the motion for the different months from May to September, and the same thing may be said of the remaining months from October to April. This result is as might have been anticipated, since, during the summer,

the weather is more uniform and not liable to so great changes, while during the spring and winter the atmosphere is almost constantly in a state of agitation.

It was stated, at the meeting of last year, that we believed great storms were preceded by a large number of small pulsations in the atmosphere, and that these pulsations were manifest in the barometer by the distance travelled by the column of mercury in any interval, as compared with the absolute change of height in the same time.

For the purpose of illustration, we will suppose the barometer has fallen 0.5 in. in 24 hours. Now, if in passing over this distance there have been no pulsations, the total motion will only amount to 0.5 in. But if on the contrary, the column has been in a state of agitation, the whole distance travelled by the mercury in falling 0.5 in. may amount to two or even three inches.

Hence we conclude that the *total amount* of atmospheric disturbance, as indicated by the motion of the barometrical column, is intimately connected with the state of the weather, the disturbance usually preceding great storms of wind, or heavy falls of rain or snow. During the year 1866, there were eight days on which the disturbance amounted to more than one inch, for the total motion of the column, and on one day the motion was over two inches. This excessive disturbance on December 27th was followed by a gale of wind, and on the next day by a fall of 16 inches of snow. And, generally without exception, these excessive disturbances were followed either by wind, or a fall of water. The storm of December 27th and 28th will be remembered by every one; it was a great storm, extending both east and west. Previous to this storm the height of the barometer only changed three-tenths of an inch, but the *total motion* was more than *seven* times as great, going to prove that the disturbance is of more importance in predicting storms than the changes of barometrical height.

The continuous record of the barometer gives us at a glance a general history of the weather. In fact, so uniform are the indications, that from an inspection of the curves, together with the records of the total motion, the direction and approximate force of the wind and the fall of rain can be determined with considerable precision. At Albany the barometer almost invariably rises under a west wind, and falls under a south wind owing, perhaps, to the influence of the valleys of the Mohawk and Hudson.

It has long been known that the barometer has a diurnal variation, due, we presume, almost entirely to temperature. From the monthly records of the past two years, we have deduced the diurnal variation. It is found that in the mean for the year, the barometer is at its mean height four times each day; viz., at noon, 8½ P. M., 1 A. M., and 4½ A. M.

The following are the times of Maxima and Minima for 1866.

	MIN.	MAX.	MIN.	MAX.
Year	4 P. M.	10 P. M.	3 A. M.	10 A. M.
Spring	3 "	11 "	3 "	8 "
Summer	6 "	12 "	3 "	9 "
Autumn	4 "	10 "	3 "	10 "
Winter	3 "	10 "	3 "	10 "

It appears from these results that the second minimum is constant for the year. The principal maximum occurs earlier, and the principal minimum later, in summer than in winter.

The daily amplitude, or difference between the principal maximum and minimum, for the year 1866, was found to be 0.063 in.

Atmospheric pressure is generally propagated from west to east, but such is not invariably the case. There is but little difference in the time at which the barometer reaches the highest and lowest points at New York and Albany, in fact, generally the curves are essentially identical. The examination of a large number of records appears, however, to indicate that, when the barometer is falling, it reaches the lowest point soonest in New York, and, when rising, it reaches the highest point soonest in Albany.

B. NATURAL HISTORY.

I. GEOLOGY AND MINERALOGY.

1. Depression of the Ocean during the Ice Period. By Charles Whittlesey, of Cleveland, Ohio.

It is a well settled truth in geology, that soon after the era of the Pliocene tertiary, a large portion, of the earth around the poles was coated with ice. It is not well settled to what this depression of temperature was due; but it will probably be found to be owing to astronomical changes, during which the angle between the ecliptic and the equator was different from what it is at present.

I do not propose to examine this question, at this time, but to show that there must have been, during the glacial period, a material depression of the surface of the ocean.

The land in the Northern Hemisphere bears abundant proofs of submergence towards the close of this period, up to elevations that are now 2,000 feet above tide-waters. Whether this submergence was due to a rise of the waters, or to a subsidence of the land, I do not propose to discuss. The change I wish to present to your consideration is one which must have taken place while the ice period was coming on and which must have been occasioned by a depression of the waters.

Accumulations of ice and *névé* can only occur on land by deposition, in the form of rain and snow, which becomes congealed. The ultimate source of this deposition is evaporation from the open surface of the sea. Inland lakes, rivers, swamps, and low lands furnish vapor to the clouds; but all fresh water basins receive their supply originally from the ocean.

The water line, or level of the sea, remains fixed, only because the amount of water taken up in vapor from its surface is returned to it through the rivers of the globe. If the water deposition on the surface of the land is not returned to the sea, it must be subtracted from the mass of the common reservoir.

The era of ice came on by a slow but regular decrease of temperature. At the present time, the area of perpetual ice is small in comparison with the entire surface of the earth; but in the glacial epoch it was much larger. Let us imagine a depression of temperature to occur now, throughout the regions towards the poles. A loss of one degree of heat (Fahrenheit) annually would cause the snow line to descend 300 feet per year, thus enlarging the area of perpetual congelation. Around the base of all high mountain ranges, all the territory 300 feet below the previous snow line would become a retaining surface, no longer giving back its depositions to the sea. Rivers would continually become shorter and smaller. The inland lakes would, in process of time, become ice-bound, and, as the continental masses accumulated, they would encroach upon the ocean itself.

In the central portions of British North America and Asia, this accumulation would attain during a long period of time a great thickness. I think the observations show that in all ice masses there is a gradual but resistless outward motion. They would not only crowd into the basins of the great lakes, but into the bays, straits, and minor seas, connecting with the ocean. The Arctic Sea would be very much diminished in extent, and the sea of Okhotsk, of Kamtchatka, Hudson's Bay, Baffin's Bay, and the Baltic, would eventually be filled up and become ice-fields, from which evaporation would measurably cease.

On the coasts of Russian America, of Labrador, Greenland, Iceland, Norway, and Siberia, the continents would constantly gain upon the sea, so as eventually to connect Europe, America, and Asia, along the Arctic Circle.

The Antarctic Continent, now occupying about 10 degrees of latitude around the southern pole, would also increase in size towards the equator and connect with Terra del Fuego, where glaciers still exist. The glacier fields of the Andes would enlarge towards the south, and join with those of Patagonia. Those of the Alps pushing northward over Switzerland, across the chain of the Jura, would meet those of Scandinavia in Central Europe. In North America there are existing glaciers on the Rocky Mountains as far south as latitude 51° north, and it is reported that Bierstadt discovered one as low as latitude 45°, of which he has given a striking picture, from sketches made on the spot.

A projecting tongue of the North American ice field would project southerly along the Rocky Mountain range towards New Mexico and perhaps into Mexico proper.

If the area of this immense field of congelation could be determined, its extent, compared with the remaining water field of the earth's surface, being known, the depression of the waters by evaporation could also be determined. To obtain the absolute depression, it is further necessary to know the duration of the ice period or the average thickness of the ice over the area of congelation.

Geologists have not yet determined accurately the limits of glacial action even in the Northern Hemisphere. In Central Asia those limits are quite conjectural. The tendency of the observations now going on is to enlarge the extent of the ancient ice-fields.

After an examination of the ancient ice areas in North America, Europe, and Asia, I regard them as equal to *one-fifth* the present land surface of the Northern Hemisphere. The enlargement of the continental spaces over the adjacent seas, including the Antarctic Continent, I assume to be as much more. If this assumption is correct, there was a period when *one-fifth* of the land of the globe presented a congealed surface, and the remainder an evaporating surface. Of this evaporating surface, however, those parts which were then land, not covered with ice, derived their water of deposition from the ocean, circumscribed in the manner I have indicated.

The dry land of all the continents is now estimated to be, in reference to the ocean, as *one* to *three*, the land embracing one-fourth and the water three-fourths of the surface of the globe; or as thirty-seven millions of square miles is to one hundred and eleven millions. Two-fifths of thirty-seven millions is one-tenth of the surface of the earth, and about fifteen millions of square miles.

We cannot, at present, fix the average thickness of the ice covering as satisfactory as we can its extent. In New England, it does not appear to have reached the tops of all the mountains, but only a height of four thousand three hundred to five thousand three hundred feet. Over the region of the great Lakes, the glacial etchings upon the rocks extend to the summits of the country, which are, however, not more than two thousand feet in elevation. The ice covering must have exceeded this height by several hundred feet.

All the country around Hudson's Bay, the valleys of the Copper Mine, the McKenzie and the Saskatchawan Rivers, is a rocky plateau, nowhere rising above two thousand feet, until the base of the Rocky Mountains is reached.

In Northern Asia, there are still larger areas which are destitute of

mountains. Over these level spaces the accumulation must have been heavier and of more uniform thickness than in more elevated and broken regions. Dr. Hayes penetrated the great mer de glace of Greenland, — a distance of seventy miles. At that distance, directly interior, it had an elevation of five thousand feet, presenting a smooth surface covered with snow. This is the largest ice field of the present era, known to us in the Northern Hemisphere; covering about four hundred thousand square miles. It is probably not an exaggerated estimate of this mass of ice, to regard it as equal to eighteen hundred feet of water over the same area, which, spread suddenly over the surface of the ocean, would raise it between three and four feet.

The Antarctic Continent is much larger than Greenland, and the ice covering is probably thicker. It must embrace from one million to one million five hundred thousand square miles. Its sudden liquefaction would give to the sea an elevation of about *twelve* feet.

In case the glacier regions of the Alps, of Arctic America, Patagonia, the Himalayas, and Arctic Asia should suddenly become warm, and the ice accumulations of thousands of centuries be reduced to water, seeking the sea through natural channels, nearly two hundred thousand square miles more of congealed matter would be returned to the ocean in a liquid form.

The density of the ice covering is another undetermined element. As compared with salt water, the icebergs of the north vary in weight or specific gravity from one-eighth to one-sixth. Their age, the pressure to which they have been subjected, and the length of time they have been afloat, each has its effect upon the solidity of the mass.

Assuming a specific gravity for solid ice of 0.90 of fresh water, an average thickness of two thousand feet represents about eighteen hundred feet of water spread over the same area. This body of water covering *one-tenth* of the surface of the earth, evenly distributed over the remaining nine-tenths, is equal to about one hundred and ninety feet. The same quantity abstracted from an ocean, covering only *nine-tenths* of the globe, would depress the level a greater number of feet; because the mass would diminish as its surface should be lowered. Besides, from the area of evaporation there should be deducted the land surface of that period, which, if it bore the same relation to the sea as it does now, would be, on the basis of my calculations, twenty-two millions of square miles to be taken out of one hundred and eleven millions. The open sea would be then restricted to less than

ninety millions of miles, perhaps to not more than one-half the surface of the globe.

From all these considerations, at the period of greatest cold, the depression of the ocean level should be, at least, three hundred and fifty or four hundred feet. As the waters retired, the configuration of all the continents would change; groups of islands, like the West Indies, would unite, forming a smaller number of islands, but of larger area; new points would appear above the ocean level, and large shoals, like those of Newfoundland, become dry land. On these newly exposed surfaces, the temperature constantly falling, and ice and snow accumulating, the general reign of cold would be accelerated. The equilibrium between the warm and fluid portions of the earth and the solid and cold portions being destroyed, the difference in favor of the frigid portions would go on increasing until checked by a return to the previous astronomical status. The belt, or zone, of temperate climate along the equator would be contracted as the frozen zones were enlarged.

When the epoch of ice reached its maximum, the return to the previous condition of the earth's surface must have been gradual. The surface of the ocean would rise; and in case a period of higher temperature than the present succeeded the ice period, the sea level must have been higher than now.

As the stability of the ocean level depends upon such slight variations of terrestrial temperature, it is remarkable that it should be so well fixed. It must be that there are compensations in nature to preserve this stability.

Prof. Hall has long advocated the theory that heavy accumulations of transported materials, at the bottom of the sea, will eventually settle by their own weight. In that case a corresponding rise should take place in some adjacent region. If this position is a sound one, heavy accumulations of ice should produce the same results. There is some evidence, now available, to confirm this theory. The coast of Greenland is reported to be sinking, and that of Newfoundland to be rising.

During the ice period, a material portion of the mass of the globe was transferred from the equatorial seas in the form of vapor, and accumulated towards the poles, along and outside of the Arctic circles. Unless there is a mode of compensation, the figure of the earth was somewhat changed by this transfer. Its oblateness would become less, and its period of diurnal revolution would be altered.

The large, level regions in British America, east of the Rocky Mountains, would be the seat of a deposition of rain, forming ice, *névé* and snow, of great thickness, as is seen in Greenland now; only the accumulation would be as much heavier as the area is larger.

The motion which occurs in all ice fields towards the sea, or towards the thawing edges, is so slow as to require extremely long periods of time for their destruction. During this epoch, a new burden rested upon the earth, along a belt corresponding nearly with the Arctic and Antarctic Circles, rising from three thousand to six thousand feet. A gradual settling of these regions may have occurred from this cause. In case this position will bear investigation and is a true one, we shall have a much better explanation of the drift plateaus, ridges, and terraces of the quaternary period, which exhibit oscillations of level. A movement of elevation only is not sufficient. They involve changes of level in both directions, alternately up and down, of which we have not sufficient proof in the sudden upheavals and depressions of the rocky strata at that epoch. On Lake Ontario we have marine clays in the same present horizon with fresh water clays on Lake Erie, belonging to the drift period. If the interior of the continent went down, the natural result would be a simultaneous rising of the adjacent coast, bringing up the marine deposits.

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2. Abstract of Remarks upon the Occurrence of Iron in Masses. By Charles Whittlesey, of Cleveland, Ohio.

I do not propose to go into local details concerning the occurrence of masses of iron ore, with the exception of the great belt of hematite ores, extending from the lower Susquehanna, in Pennsylvania, northeasterly through New Jersey, New York, Connecticut, Massachusetts, and nearly through Vermont; neither shall I speak of the ores of the coal series, which occur in thin bands and not in masses.

On this general map of the United States and of Canada, I have colored the important iron centres black, but the scale is too limited to represent their form and extent in proper proportions. The first mountains of iron ore which attracted attention in this country were those of Missouri, about eighty miles south of St. Louis. Here the iron knobs, masses, and mountains appear, like the degraded edges of

heavy ferruginous strata, in metamorphic beds, which have a porphyritic aspect. The ore is nearly pure specular oxide, in inexhaustible quantities; although the territory over which it is found is much less than in Michigan.

About five hundred miles north of the iron mountains of Missouri, on the waters of Lake Superior, occur the iron mountains of Michigan and Wisconsin. Those in the latter State occupy a belt about thirty miles in length, extending south-westerly from the boundary on Montreal River, at a distance of ten to twenty miles from the lake. This ore is *wholly magnetic*, and occurs as a stratum, in a belt of stratified azoic quartz, dipping north-westerly at a high angle beneath the copper-bearing trap. It is fine-grained, black, frequently laminated, in plates with sharp edges, free of sulphur, phosphorus, arsenic, or other chemical impurities. The quantity is inexhaustible, — probably the accompanying rocks are metamorphic. They are almost entirely composed of silex, or silex and hornblende. The order of succession downwards is

1st. *Potsdam Sandstone*, of great thickness, at least ten thousand feet, dipping north-westerly at a high angle of seventy to ninety degrees beneath Lake Superior.

2d. *Copper-bearing trap*, a continuation of the Point Keweenaw Range, dipping conformably under the sandstone.

3d. Rocks of a trappose cast externally; but the analyses show no relation to trap, highly crystalline, red, blue, and black, dip conformable to the superior beds, but not as steep; thickness two to two and a half miles.

4th. *Quartz beds*, conformable and often slaty; thickness, half a mile; color white, gray, blue, and black; a band of magnetic ore near the centre, but not everywhere workable.

5th. *Granites and Sienites* of Central Wisconsin. No crystalline limestone has yet been discovered in the formations here noticed.

It is about one hundred and ten miles to the eastward of this iron belt to the exposures of iron slates, on the head waters of the Menominee River, near the Twin Falls, on the boundary between Michigan and Wisconsin. Here ferruginous masses form an important portion of the azoic rocks. They are both magnetic and specular. The adjacent rocks are siliceous slates, red, gray, dun, and black, all containing iron. There are hornblende slates and flags, and bands of blue, gray, red, and variegated marble.

Proceeding north-easterly from the Menominee towards Marquette, the rocks become more trappose, and the iron ore, which is principally specular, but sometimes magnetic, becomes less slaty and more massive. The iron district is irregular in form, the longest, or east and west diameter, being about one hundred miles, and the north and south fifty miles in length. Heavy beds of quartz and dolomite characterize this region; but there cannot be traced in it the regular stratification of the Montreal and Bad River country. Both the quartz and the marble constitute immense elongated, flattened, and crooked bunches, not extending through the region as a connected system. In the easterly part of this great iron-producing field, nearest to Marquette, the trap ranges, and their huge bunches of ore, partake of the same form and irregularity. The field is known as part of the azoic series, in the Reports of Foster and Whitney, embracing, in addition to the marbles and siliceous slates, some micaceous schists and argillaceous and hornblende slates. It is bounded on the north and south by mountains of sienite and granite, having enclosed masses of hornblende rock, and occasionally dykes.

In the Canadian Reports, the Azoic system of Foster and Whitney is regarded as metamorphic, and divided between the Huronian and Laurentian formations.

Adjacent to the masses of ore hitherto wrought, is a rock which the miners call "greenstone," generally a homogeneous, but sometimes slaty, soft, light green rock, forming mountain ridges, the analysis of which corresponds with trap. It contains a large per cent. of oxide of iron, and passes gradually into workable ore. There is no regularity of dip among these greenstone ridges, nor in the included ore beds, nor are they continuous or strata-like in the direction of the ridges, but only more elongated in that direction. The ore masses are not separated by planes of division from the adjacent rocks. All of the rocks, composing the iron-bearing series, extend easterly into the Lake, at Marquette; but no workable masses of ore have been found nearer to navigable water than fourteen miles. A railway extends about thirty-five miles into the region to Matchigamni Lake, without reaching its central portions. The supply is incalculably large; and its present importance is shown by the amount of ore shipped, or manufactured in 1867, which exceeds four hundred and fifty thousand gross tons. Of this, about three-fourths is specular, the remainder mostly hematite, forming a portion of almost every mine, and a few thousand tons of magnetite.

In the Laurentian system of Canada there are several remarkable deposits of iron ore, principally magnetic and crystalline. They are found on Lake Nepissing, north of Lake Huron, at Bay St. Paul, on the St. Lawrence, where the ore contains a large per cent. of titanic acid, and on the Rideau Canal, at Mud Lake, midway between Kingston and Ottawa. But the largest masses, approaching those of Michigan and Missouri in size, are at Marmora, near the gold field of Madoc, on the waters discharging into the Bay of Quintè. None of these mines have as yet furnished much ore to commerce, owing, probably, to the low state of iron manufacture in Canada.

The rocks composing the mountainous region of Northern New York are outliers of the great Laurentian field in Canada. Here, over a space nearly one hundred miles in diameter, iron ore, in general of the magnetic variety, is everywhere found. It occurs in veins or beds, or both, different explorers using these terms interchangeably. The ore is not found in masses like those at Marquette. Large numbers of the deposits are, however, thick enough to be wrought. It is only the rough, impracticable character of the country which has prevented the vast iron region of the Adirondack from being penetrated by railroads, and exposing numberless mines. At present, only the eastern edge of the region, which approaches within a few miles of Lake Champlain, is accessible. The ore is even yet brought to navigation by teams over rough roads, from whence it is shipped to the furnaces on the waters of the Hudson. A few thousand tons are annually transported to the works in Ohio, at and near Cleveland. It is generally crystalline, easily crushed, makes a tough metal, and is particularly good for lining to puddling furnaces. Besides the micaceous and quartzose beds of the Northern Laurentian, the New York portion of the formation, especially the south-eastern portion of it, embraces hypersthene rocks in great force; but the limestones are wanting. On the waters of the Oswegatchie, near the junction of the overlying Potsdam, in St. Lawrence County, there are large irregular deposits of red ochrey hematite. In connection with these hematites are elongated masses of crystalline limestone, such as accompany the hematite beds of the Taconic range in Connecticut and Massachusetts. After penetrating from the hematites, on the Oswegatchie, a short distance eastward, into the Laurentian field, the black, rich, magnetic ores of the Adirondack are met with, having the usual form of beds, or veins, perhaps both. Wherever this wild region has been penetrated, whether

by hunters, fisherman, or explorers, their reports agree, that iron ore exists in quantities literally inexhaustible.

Thus the notable deposits of magnetic and specular iron ore are found associated with the quartz rocks, hornblende rocks, porphyry, micaceous schists, and dolomitic marbles, composing the most ancient metamorphic series. If the metamorphism of the Laurentian and Huronian formations shall be regarded as an established geological fact, the separation of the oxides of iron from these rocks into veins, beds, and masses can be easily accounted for. All sedimentary strata contain the oxides of iron; and any agent powerful enough to change the crystalline form of rock would bring about a concentration of their minerals. Metals, their oxides and salts, possess an inherent quality of segregation. Whenever the condition of the enclosing strata is such as to allow of motion among particles having the affinity of segregation, they must obey this affinity and become more concentrated. The points about which the concentration takes place are determined by the accidents of fracture, change of density, divisional planes, and even by the presence of fossils.

There are very important deposits of iron oxide in the sedimentary rocks of the United States that do not come under the head of masses. Of these, the most persistent and wide-spread is that belonging to the Clinton group of limerocks which is generally oolitic in structure. In Wayne County, New York, there is a remarkable outcrop of this ore about twenty miles in length. In Wisconsin it has been opened in Dodge and Brown Counties, several feet in thickness. On the Upper Juniata, in Pennsylvania, and thence south-westerly, in the same formation through Maryland into Virginia, it has been discovered and worked at numerous points. It exists in force in the same geological horizon in Eastern Tennessee, extending southerly into Alabama, under the name of "dyestone ore." As a general rule, it produces a soft iron of superior quality, and is very easily reduced in the furnace.

But the iron-bearing belt, which is best known to manufacturers because it has been longest and most extensively wrought, belongs to the Green Mountain range of Vermont, and extends thence southerly through Massachusetts, the north-western corner of Connecticut, and Eastern New York, crossing the Hudson River near Fishkill, thence across the north-western part of New Jersey into Pennsylvania, and across the Susquehanna into Maryland, — a distance of, at least, three

hundred and fifty miles. A large part of this range is now regarded as a part of the lower silurian system, in a highly metamorphosed condition.

After crossing the Hudson, the hematites diminish in quantity, being partially replaced towards the south-west by magnetic ores, or by beds, veins, and masses containing both varieties. The same metamorphic belt, existing in very different degrees of change, which extends southerly through Virginia and North Carolina into South Carolina, near King's Mountain, carries everywhere deposits of iron ore, but more magnetic than hematite. In this quarter, no great mines have been opened; not from the lack of ore, but from the absence of enterprise. The most southerly mine, developed on a large scale, is the famous Cornwall ore bed, in Berk's County, Pennsylvania. According to Mr. Lesley, it belongs to the Upper Potsdam. The ore is principally hematite, with pyrites and some magnetite. There are trap dykes intersecting the mass, to which, no doubt, some of the metamorphism and segregation is due. Similar masses are well developed in the same horizon in Buck's and Lancaster Counties at Chestnut Hill, and at the Warwick mines.

In order to compare the mode of occurrence here with that in Connecticut and Massachusetts, I quote from Lesley's exhaustive work on the Iron Manufacture of the United States, p. 560, — a local section made by Prof. Rogers. The mine, near Safe Harbor, on the Susquehanna, had, in 1858, reached a depth of one hundred and thirty-eight feet. It is situated between Potsdam slates and magnesian limestone, F. 2, dip 40°.

	THICKNESS.
1. Mica slate,	14 feet.
2. Sandy ore,	not given.
3. Brown hematite ore, solid,	6 feet.
4. Mica slate,	10 "
5. Blue talc slate,	30 "

It is to these remarkable hematite bunches, extending from the Susquehanna north-easterly to and across the Hudson, and thence to the Otter River, in Vermont, that I propose to devote the remainder of this paper. There has been a great diversity of opinion among geologists on the origin of these deposits. By hastily grouping their leading characteristics, light will be thrown upon this question. A group of hematite mines about Saegersville and Trouton, in Lehigh County, Pa., which have been long wrought, are in close relations with

lower silurian limerock. This association with limestone, generally crystalline, is the marked feature of the massive hematites. The extensive mines near Allentown and Bethlehem, Pa., are also in contact with limestone beds of the same age, constituting in an altered condition, the "Quebec Group" of Canada. On the same geological range, travelling to the north-east, in New Jersey, near the line of New York, at the base of Pochunk Mountain, is a repetition of the red hematite masses. Its dip is steep to the east-south-east, lying between beds of gneiss, altered felspar or kaolin, and crystalline limestone, belonging to Formation No. 2.

The Townsend mine, at Cornwall, Orange County, N. Y., is in the same formation. At Westchester, N. Y., the ore is alternated with layers of clay (altered felspar) and sand. At the Prescott Bank, in Hillsdale, crystalline limestone forms (according to Prof. Hodge) the base of the mine. The Fishkill mine is between strata of limerock. F. 3 (Hodge). Its section is thus: ore, with a band of slate, fourteen feet; clay, fifteen feet; ore, six feet. In Columbia and Duchess Counties, N. Y., the ore lies generally at the junction of the Potsdam and calciferous (F. 2), resting on limerock, with mica slate above. The dip is twenty to sixty east (Mather). The Amenia banks are between talcose, or talco-micaceous schists and limestone.

In Dover, N. Y., six miles west of the Housatonic River, the nearest visible rocks are the mica slate (Hitchcock).

Proceeding northerly, there are old openings at Kent, on the Connecticut and New York line, where the foot-wall is micaceous gneiss, then ore and green earth twelve feet thick; dip easterly, 60° to 80°. At Indian Pond in Sharon, Conn., just south of the Taconic mountain, is the same ore, a little flatter, the dip being about 45° east.

The most ancient and the best developed of the iron mines of this range are at Salisbury, Connecticut, a township situated in the north-west corner of the State, the west line abutting on New York, and the north line on Massachusetts. Iron was made from the "Old Ore Hill" Bank as early as 1748. At present the principal excavations are known as Chatfield's, the "Old Ore Hill," and Davis'. In Mr. Lesley's view, the Chatfield Bank is on or near the crown of an undulation, the dip being to the east about 50°.

The Old Ore Hill Bank is but a short distance north of Chatfield's, and the exposure is more extensive. It rests on quartz bunches

which pass into the micaceous, or talco-micaceous mass of the Taconic mountain, that rises rapidly to the north, attaining the general altitude of the Green Mountain range, of which it forms a part. The strike is north-east; the dip 50° to 60° south-easterly. These layers are not strictly conformable to the face of the micaceous portion, but a little flatter. When I examined it in 1858, the space then worked by the miners, measured across the beds, was seventy feet wide, in which there were visible four warped beds composed of fibrous quartz, and a talcose material which the workmen call "white horse." These corrugated beds were gray, white, and red; the fibres, or needle-like crystals of the quartz, standing at right angles to the surface of the layer. The space between the strata was occupied by kaolin, clay, ochre, and hematite. Much of the ore is crystallized in bunches and geodes, the crystals radiating from the centres, or other surfaces, which are polished, and show brilliant black and iridiscent colors. There are crystals of felspar in the ore, which lies not in flat bands, but in bunches, surrounded by felspathic clay that passes into ochre. Along the eastern foot of the mountain to the north-east are several openings, the principal of which is the "Davis Mine," about four miles from the Old Ore Hill, and a mile south-west of the centre of Salisbury. Here are the same variegated layers of talcose, aluminous, and siliceous matter, also warped and twisted, having the same general inclination to the south-east, varying from 20° to 40°. As at the other mines of the hematite series, the ore is covered with a heavy deposit of coarse drift, which conceals the ore sometimes to a depth of twenty or thirty feet, and must be carted away as the work progresses, causing a heavy and constant expense for dead work. On the side next the mountain there is here a bed of crystalline limestone which is not conformable to the iron-bearing layers, but dips north-west at an angle of 45°. This is doubtless due to local disturbance. On the east the valley of the Housatonic is occupied by the same limestone in great force. According to Mr. Percival, the ore lies between this metamorphic limerock (Formation M) and the talco-mica slate.

On the west side of the Taconic mountain in New York, near Middleton Station, on the Harlem railway, two miles west of Ore Hill, a mine has been wrought for many years for the use of Dakin's furnace. This is partly around the mountain to the north and west, and although the iron-bearing layers are somewhat confused, their dip is to the east very sharp, or 70° to 80°, thus pitching under the

mountain and the Old Ore Hill. The dolomite, "white horse," and mica-slate still form the body of the strata, with felspathic clay, ochre, and iron ore.

Below is a bed of limerock of a dark color. Travelling northward along the western base of the range, near the Massachusetts line, at Boston Corners, the same ore is mined to a limited extent. President Hitchcock (Mass. Reports, p. 573) says the limestone here alternates with argillaceous slate, containing organic remains; the whole dipping rapidly, say 80° to 90°, to the east. At Copake, still farther north, the ore is interstratified with mica-slate above the ore, and limerock below, all pitching eastward beneath the mountain.

Before noticing the hematite deposits farther north, in Massachusetts and Vermont, I will repeat President Hitchcock's general sections of the rocks of the Green Mountain range in Massachusetts.

East and west profile near the south line of Massachusetts. Dip east 60° to 90°.	East and west profile near Richmond, Mass. Dip east 60° to 80°.	East and west profile near the north line of Mass., Saddle Mountain. Dip east 50° to 80°
1. Argillaceous slate in New York.	1. Argillaceous slate, New York.	1. Argillaceous slate, New York.
2. Blue limerock.	2. Limerock, bluish color less crystalline than No. 4 slate line.	2. Wanting.
3. Talco-micaceous schists, Mount Everett.	3. Talco-micaceous schist, Lenox.	3. Talco-micaceous schist, slate line.
4. Crystalline dolomite, Sheffield, 10 to 12 ms. broad.	4. Crystalline dolomite.	4. Crystalline dolomite, Williamstown.
5. Micaceous schist.	5. Wanting.	5. Talco-micaceous schist, Saddle Mountain.
6. Wanting.	6. "	6. Crystalline limerock, North Adams.
7. Quartz rock (Potsdam)?	7. Quartz rock.	
8. Crystalline limerock, N. Marlboro.	8. Gneiss.	

The ore beds are thus seen to be everywhere conformable to the other strata of the range. At West Stockbridge, Lenox, Richmond, and Great Barrington, in Massachusetts, the best developed mines are found at the junction of the micaceous bed, No. 3, and the dolomite, No. 4, which is the position of the Chatfield Old Ore Hill, and Dorr's Banks, in Salisbury. The ore at Dakin's, Boston Corners, and Copake, in New York, skirts the edge of the blue limerock, No. 2, and corresponds with the position of the Vermont mines.

Through the Salisbury mines the section is the same as Nos. 1, 2, 3, 4, and 5 of the most southerly profile in Massachusetts, the broad belt of crystalline limestone, No. 4, filling the valley of the Housatonic. It carries small crystals of sulphuret of iron, and also the protoxide of iron, amounting, according to President Hitchcock, to *four and one half per cent.* In general, the limestone of the Green Mountain range shows disseminated iron. At Salisbury and Great Barrington there are limited quantities of pyrites in the mines.

The blue limerock, No. 2, and the white, No. 4, extend northerly into Vermont; but heavy masses of ore have not been developed in them in the north-western part of Massachusetts.

After the slate line is passed, along the western base of the range in Vermont, the hematites reappear in large bodies, having the same geological relations as farther south, — the dip of the strata being uniformly east. There are workable mines at, or near, Bennington, Dorset, Chittendon, Pittsford, and Wallingford. At North Dorset, according to the late Prof. C. B. Adams, the layers of clay, ochre, and hematite, of the Laconic Mountain, are repeated with an inclination 12° east. At Pittsford they are steeper, or 55° to 60° inclined in the same direction.

The Chittendon mines, in Rutland County, present the same bands of quartz, clay, ochre, and hematite, in contact with talcose slate and limestone, pitching rapidly east (Vermont Reports). This ore carries a large proportion of manganese like many other mines of the Green Mountain and Taconic range. At Wallingford, the iron belt is two hundred and fifty to three hundred feet thick, resting upon limestone, with a dip to the east of 60°. The Brandon mine, in Rutland County, which has become famous on account of its lignites, and recent vegetable fossils, presents no exception to the system of hematite beds. I have dwelt upon the local sections of these mines, because it is not many years since they were considered as belonging to the tertiary. The information we now have makes them, beyond controversy, a part of the Green Mountain system, which is generally considered as the metamorphosed condition of those level silurian beds next above the Potsdam. The iron ores thus belong to the upper part of the "Quebec Group" and the lower portion of the "Trenton Group" of the Canadian Reports. Those eminent geologists, who first studied the hematites of this range, were quite unanimous in regarding them as the result of very recent geological changes, probably because the

ore is a hydrate, and its surface associations are drift gravel and clays. The singular discovery of fossils of the present era, in this ore at Brandon, gave new strength to this theory. But more recent investigations show that hematite is not necessarily of sedimentary origin. Hydrates are common in rocks which are still regarded as igneous. Throughout the masses of specular ore, in Marquette County, Michigan, are large bunches of hematite, so extensive as to form a material part of the ore now mined. Hematites are too extensive and too far below the surface to admit a general theory of recent and local changes.

Depth has disclosed no modifications in the ores of the Green Mountains; and since these beds were subject, on account of their softness, to great destruction by the drift forces, the bottom of the present mines, in some places more than one hundred feet down in ore, must be regarded as much more than that distance below the original surface. The causes which concentrated the ore along this line of several hundred miles, everywhere in contact with metamorphic limestone, must have been universal and not local. Iron in some form exists in all rocks. The limestone beds of the Clinton and the Hudson River group are charged with it, especially near their junction, where the oolitic or dye-stone ore is generally found. If these strata should undergo a molecular change, whatever the agent might be, it must act, at the same time, as a concentrator of their mineral contents. In this action, limestone seems to be an almost necessary medium or facilitator. The belief in a wide-spread, almost an universal, metamorphism of the rocks is rapidly gaining ground. In this mysterious but acknowledged force, which produces a new crystalline arrangement, have we not all the required agencies to produce masses of any mineral which existed in the strata prior to the change? Is not something more necessary to account for these results, — some cause more universal than local chemical action?

In a practical point of view, this hasty grouping of our most prominent iron mines demonstrates a capacity of production in this country which has no parallel in other nations.

3. Considerations Relating to the Climate of the Glacial Epoch in North America. By Edward Hungerford, of Burlington, Vt.

The considerations here presented relate more particularly to the climatic influence of an extended accumulation of snow and ice in the higher latitudes, such as the glacial hypothesis supposes to have once existed.

1. Such a snow mantle, gradually extending itself into more southern latitudes from the north, presupposes the successive introduction of a diminished summer temperature into each such latitude.

2. A *depression* of the drift area would restrain the extremes of summer temperature, rendering the climate more insular, and might, under a rearrangement of the northern marine currents, diminish the mean temperature of that season of the year.*

3. But the fact that glacial markings are found at all elevations, in the low valleys as well as in the higher regions, renders it probable that, during the period of accumulation of the snowy mantle, the continent was at least as high as at present; for the ice-cap and its markings could not be formed over portions covered by the sea. The diminished summer temperature of that period, therefore, if not produced by a cosmical cause, was the result of an elevation of the northern latitudes, or of some portion of them. A depression of the summer temperature, from this cause, would not be accompanied by a fully corresponding depression of the winter temperature.†

4. A glance at the present arrangement of the lands in the north polar regions of the continent suggests that a moderate elevation of those lands, above their present level, would produce very great climatic changes by establishing continuity between the at present numerous detached, insular masses, thereby excluding the oceanic waters from northern bays and straits. Such changes might be sufficient greatly to extend the area of perennial snow in that section, and to initiate a

* Iceland and the interior of Norway, between the 60° and 62° parallels have nearly the same mean annual temperature, but the summer temperature is lower in Iceland, and the snow line is much lower than in the interior of Norway.

† This follows from the considerations advanced in paragraphs ( ) and (2) under 6, which apply equally to the latitudes under consideration, in winter, at the present time, and under their present elevation.

process which should result in the glaciation of even the lower northern latitudes, without necessarily involving any very extended upheaval of the earth's crust in those lower latitudes. For, the process of snowy accumulation having been once begun in the extreme north, it is to be remembered that the direct climatic influence of every one hundred feet of such accumulation would be fully equal to the same amount of upheaval of the territory over which the accumulation takes place. The result will be to still further depress the summer and, to some extent, the winter temperature, and to provide for the further extension of the snow line southward. So long as the snow or ice-cap continues to be built up, so long the consequent climatic changes will extend southward, until some great reactionary cause is introduced. There would thus be developed the vast frozen mantle which the glacial hypothesis contemplates, — an elevated plateau of snow and ice extending over the present drift regions.

5. The frigorific effects of such a gradually extending accumulation of snow and ice, having a thickness of several thousand (from five thousand to possibly ten thousand) feet, may be noted as follows: —

(1.) The northward moving warm currents will be partially deflected by the icy barrier against which they impinge, thereby depriving the area to the northward of their influence.

(2.) The same warm currents will be partly elevated along the slope of the glacier front, and by the process of elevation their temperature will be depressed.

(3.) Consequent upon this loss of heat by elevation, as also upon that by contact with the glacier front, come loss of aqueous vapor and heavy precipitation along the outer margin of the ice cap. Such south winds, penetrating into the interior, will thus become comparatively dry, while the still colder and dryer north winds have free sweep over the plateau. Such dryness of the atmosphere facilitates radiation from the underlying surface, and becomes an important additional cause of cold.*

(4.) The direct radiation from the aqueous vapor of the atmosphere, the pouring of its own heat into space, is facilitated at such elevations by the absence of a superior stratum of vapor which would act as a screen, preventing radiation. At lower elevations such a screen of vapor still exists above the stratum of air next to the earth's surface.†

* See Tyndall's experiments on absorption of heat by aqueous vapor. "Heat a Mode of Motion. Lecture XI."

† See the same work, pages 402 and following.

6. To these climatic effects more directly arising from the elevation of the plateau, we have still to add those which spring from the peculiar nature of a snowy surface, and which bear in the same direction towards the reduction of temperature.

(1.) The reflecting power of a snowy surface, by virtue of which it turns back the sun's rays into space, would deprive the earth of an immense amount of heat, which would otherwise go to temper the climate.

(2.) In a region free from snow, the heat which is not reflected is absorbed in vast quantities, to be again radiated from the earth, and to temper the climate. The bare earth serves as a great storehouse of heat. But owing to the low conducting power of snow, the larger portion of that heat which is not reflected from its surface is applied first to raise the temperature of the superficial snow only so far as to 32°, and then to convert it (if there be so much heat) into water which flows away, bearing its heat, thus obtained, into distant regions. Cold northerly winds blowing over such a snow-covered terrace, would, therefore, miss the moderating warmth that comes from a reservoir of heated land.

7. All the above considerations, it will be seen, point to the *prevalence of a severe* climate over the snow-covered country. To the usual effects of elevation, we have added, in this case, the peculiar effects flowing from the material comprising the plateau. Under the combined operation of these various causes, we may be justified in assuming that, at a distance not very remote from the southern margin of the ice-mantle, a climate of great severity would prevail throughout the entire year. This result accords also with the natural inference that the existence in the lower drift latitudes of a temperature sufficiently low to admit of prevailing perennial snow in them, as it involves the supposition of a severer cold for each successive latitude, in passing northward, must result, over a large portion of the territory back from the southern margin, in a rigorous winter temperature, even in our summer months, while the winters themselves would be periods of intense cold. Manifestly in the case before us the rapidity of diminution of temperature, or the difference of climate in passing northward, would be determined by the combined influence of difference of latitude, and of elevation of the snow plateau.

8. The confessed influence of temperature on the rate of glacier-motion gives importance to these considerations, on account of their

bearing on the motions of a continental glacier. The prevailing severe cold of the interior regions would be prejudicial to motion, and, without a favoring general slope of the country in one determinate direction, might even limit the motion to simple, irregular, local adjustments of equilibrium in the glacier mass.

On the southern margin, however, the two favorable conditions of glacial motion would always be realized. Here the climate would be comparatively mild, while the elevation of the glacier's front would itself be equivalent in effect to a sloping surface. The abundant snowy precipitation in the higher regions would supply the loss from melting in the lower.

9. Each successive belt of the present drift country would be twice subjected, for a long period, to the influences of glacial motion; once during the development of the snow mantle, southward, and once during its final retreat northward.

10. We are thus furnished with the means of accounting for all the erosive glacial phenomena, as well as for the transportation of the nearer drift and for the residual moraines, without resorting to a general, simultaneous, southward movement of the glacial mass throughout its entire length and breadth.

For the transportation of the remoter drift the agency of icebergs and ice-rafts would seem necessary.*

* As this paper relates particularly to the climatic effects of the hypothetical snow-mantle itself, it was not thought necessary to introduce the very obvious consideration, that such an immense accumulation from atmospheric precipitation, as it demands, on the one hand, a good condenser, requires, on the other, a heated reservoir of water, from which the aqueous vapors may be derived, — a consideration which strongly militates against the extreme southern extension of the ice period, or of continental glaciers, by Mr. Agassiz. It is in those southern regions we must suppose such reservoirs to have lain.

4. Ripton Sea Beaches. By Edward Hungerford, of Burlington, Vt.

(ABSTRACT.)

In this paper the author gives detailed evidence of the aqueous origin of these deposits which occupy the sides of the pass through the Green Mountains, in Vermont, through which runs the road from Ripton to Hancock. The deposits are elevated 2,196 feet above the sea on the western slope of the mountains. Drawings of the terraces were exhibited, and a section showing three or four terrace levels, one above the other. The configuration of the country is unfavorable to the accumulation of any large body of fresh water in this vicinity.

The existence of such elevated terraces, in connection with other facts, leads the author to infer that, subsequent to the true glacial epoch, the country was submerged to, at least, the level of these terraces. His views upon this point were stated as follows: —

Accepting the possibility of such a climatic change as should result in the formation of an ice-cap over the northern portions of the continent, it is contended that the rigors of the fully-established winter, combined with the absence of any favoring slope, render the assumption of a general, simultaneous movement of the glacial mass in one direction a too doubtful one, that it should be relied on to account for the transportation of the boulder drift to distances of hundreds of miles from the parent rock.

On the other hand, the milder climate which would obtain on the southern, or seaward margin, of such a glacier, coupled with the slope of the front of the glacier, or with its unsupported face, would secure an abundantly free motion throughout a certain belt on the outer border. This moving belt would have its waste supplied by the heavy precipitations of snow upon the higher regions of the belt, which represent the *névé* regions of present glaciers.

During the advance southward, and during the final retreat northward of the great glacier, each successive belt of country would in turn be twice subjected to glacial erosion. The drift material would also, by this means, be transported to a limited distance, while for transportation of the remoter drift, as well as for the explanation of other phenomena, and especially the lower modified drift and the higher sea-beaches, a gradual submergence of the still ice-covered con-

tinent is necessary; and to such submergence the return of a milder climate may be ascribed.

In the progress of such a secular submergence, the sea would be brought in contact with successive portions of the great ice-belt, and icebergs of colossal extent would be set afloat all along the border of the glacier, which is constantly pushing itself forward into the ocean. Immense ice-fields, grinding upon the bed of the ocean, and on the coast, would still keep up the degradation of rocks, and of loose material, the finer portions of which would be partially distributed by currents. Such icebergs and ice-rafts would furnish the means of transportation to any distance.

As the ocean continued to encroach upon the land, the line of the ice-mass would become broken by deep indentations, which might account for (some) deflections in glacial striæ; the direction of flow, in such cases, being turned locally toward the nearest sea.

It is not necessary to follow out the details of this process. Long after the seas, in lower latitudes, had become partially freed from ice, the ice-barrier in the north would still send down its ice-fields and bergs, the later continuation of which process is still going forward upon our eastern coast.

Upon the re-emergence of the continent, the originally deposited drift would be, in part, remodelled by the waves. Smaller boulders would be rolled and the striations often removed, while partially or completely stratified deposits of finer material would be accumulated in favorable localities. The earlier periods of this emergence are marked by the elevated beaches. The later ones are represented by the Champlain clays and sands with their marine shells of recent species.

The events here enumerated succeed each other in the following order: —

1. The formation of a continental glacier, to whose partial and limited movements are due the erosive phenomena and the transportation of the drift over limited areas.

2. A depression of the continent, bringing the ocean in contact with the long glacial border, which, in its retreat, sends off icebergs and ice-rafts into the ocean. To these are attributed the further work of transportation of detritus and boulders.

3. Emergence of the continent, the higher beaches marking the earlier, and the Champlain terraces the lower stages of this process.

5. On the Lower Silurian Brown Hematite Beds of America. By Benjamin S. Lyman, of Philadelphia, Penn.

In the south-eastern part of Smyth County, in South-western Virginia, within half a dozen miles south and east of the town of Marion, between that town and Iron Mountain, are thirty or more iron ore banks and natural exposures of lower silurian brown hematite, such as are found in such numbers along the Great Valley of Virginia and its continuation north-east to Canada and south-west to Alabama. A rough topographical survey of a part of this iron district near Marion shows, by means of two or three parallel sections from north-west to south-east across the general strike, that the rocks form two important saddles with a basin between, and that the ore exposures occur at corresponding distances on the opposite sides of the northern saddle and of the basin, as if they were the outcropping of four beds of ore regularly bedded with the other rocks; and at three (or four) of the ore banks the solid beds are to be seen. At the other exposures the ore has the same appearance as at almost all such exposures throughout the valley; namely, it is in solid lumps of irregular shape and of every weight up to three hundred tons or more, scattered irregularly through brown gravelly loam. The brown hematite is sometimes very pure, but often contains rounded or angular grains or pebbles of white quartz, and sometimes is merely a cement that binds together angular pieces of light brown sandstone. All these beds seem to lie within the Virginia and Pennsylvania Geological Formation No. I., wholly below the calciferous sand rock of No. II.

These brown hematite exposures of Smyth County resemble very closely in every respect a great number of similar ones of lower silurian age, from New Brunswick to Alabama, that are described either originally or at second-hand in Lesley's "Iron Manufacturer's Guide." Among these are a dozen or more that show the ore to be unmistakably in regular beds conformable to the other rocks. A few of the deposits seem (like Mr. David Graham's iron ore in Wythe County, Virginia) to come from the weathering of the upper part of a fissure vein of iron pyrites. The rest are more or less irregular deposits of loose lumps of ore of various size and shape scattered through brown loam, sometimes with white clay or sand, and the

lumps are commonly less mixed with these other materials at a depth from the surface of the ground. There seems, indeed, to be nothing in these deposits to remove the impression made by the correspondence in position, by the solid bedding occasionally visible and by the other characteristics of the Smyth County exposures, that the iron ore was deposited in regular beds of greater or less extent and thickness at the same time as the other rocks, and that they have been broken into fragments at their outcrops, and that these fragments of hard and heavy ore have accumulated in quantities of various extent according to the lay of the ground, mixed with the loam that comes from the more thorough comminution or decomposition of the other softer rocks and of a portion of the ore itself. The lumps of ore are sometimes stalactitic in form and sometimes are hollow geodes; and these forms may have existed in the original beds, or they may perhaps have originated later in some cases. These deposits of loose lumps of brown hematite in loam seem, then, to be similar to accumulations of outcrop blocks of any bed of rock, such as sandstone, for example, or to the black dirt of a coal outcrop, except that the effect of the hardness and heaviness of the ore must be regarded. They are like the alluvial deposits of gold and tin ore, except that the lumps of iron ore are larger, owing to its coming from thick, solid beds, and it is lighter. As the lumps of ore in such deposits have been accumulating ever since the denudation of the rocks began, there might easily be found among the ore or near it, not merely the more or less decomposed outcrop rubbish of neighboring rock beds, but now and then comparatively recent vegetable deposits like the Brandon and Mont Alto lignites. At two or three points in Virginia and Pennsylvania, lumps of carbonate of iron have been found mixed with this brown hematite, and this would go to show that the ore was originally deposited as a carbonate like the coal measure beds of carbonate of iron, and has since been changed into brown hematite either in the solid bed or in the lumps scattered through the loam, a change that happens so often with the coal measure carbonates. The greater age of the lower silurian ores would not probably make the change more complete in their case, for they seem to have been thickly covered up until after the carboniferous epoch; but the position of the lumps of ore in loose loam would be especially favorable to the change.

This view of the origin of the deposits of loose lumps of brown hematite in loam may be of great practical importance, since it would

help to show by the dip of the rocks and the lay of the ground something of the probable size of such a deposit, and in which direction a solid bed of ore might be looked for. The solid beds of ore may, however, be much less regular in thickness than the beds of iron ore of later age, and very likely resemble in this respect the early beds of magnetic iron ore.

The supposition some have entertained that these lumps of ore are derived from the percolation through the loam of water charged with iron dissolved out of rocks that contained iron in the form of iron pyrites or otherwise, and that the lumps are therefore concretionary in origin, and the result of a segregation so thorough that it sometimes leaves white clay or sand in contact with the ore, has more than one difficulty. The lumps are commonly not of the shape of concretions, for these must be more or less rounded or nodular, as they are formed about centres, and they could never be irregularly angular. The coal measure nodules of iron ore are placed also with a certain regularity in the slates where they occur, and not a trace of any such regularity is found in the lower silurian lump deposits. It seems hard, too, to conceive of so complete a segregation as would be necessary, in loose, gravelly loam; and it would be more natural to expect that iron-bearing waters, in soaking through such loam, would form an iron ore comparatively homogeneous, but mixed throughout, with the impurities of the loam. It would seem, rather, as if the effect of the percolation of the water in these deposits had been commonly to give a ferruginous covering and character (taken from the ore) to the materials of the loam when they came from rocks that did not have that character.

The strength of the argument furnished by these Smyth County ores depends in a measure upon the accuracy of the survey; but although this was but rough, the limits of error in each cross section are so small compared with the distances apart of the different beds that, in a similar case, the identity of coal beds exposed on opposite sides of a saddle or basin would be quite undoubted, and the uniformity in these distances over a space of several miles is even surprising. The correspondence of the beds in the different cross sections is, however, somewhat less certain in some parts. On one section the outcrops of the four beds are exposed on each side of the northern saddle, and probably the three upper ones are exposed on the north side of the southern saddle; then on a section about two miles to the east,

the three lower beds seem to be exposed on the north side of the southern saddle; and on a section two miles and a half still further east the upper and lower beds seem to be exposed, also on the north side of the southern saddle. A little allowance must be made in two or three of these places for the slipping of the ore lumps down hill from the real outcrop of the solid ore bed. The exposures marked in these sections are almost all very near to the section lines, so that there can be no appreciable error from any possible slight mistake in the direction of the strike, in projecting the exposures upon the sections; and, with occasional small allowances for slipping of the ore lumps down hill, all the other exposures observed correspond well with the theoretical outcrops of the four beds.

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6. On Recent Geological Discoveries in the Acadian Provinces of British America. By J. W. Dawson, of Montreal, Canada.

(abstract.)

The object of the paper was to notice some recent discoveries which, though of interest, might have escaped the notice of members of the Association.

In New Brunswick, the older rocks in the vicinity of the city of St. John have been reduced to order, and their probable ages ascertained, principally through the labors of Mr. Matthew, Mr. Hartt, and Prof. Bailey. The first step toward the knowledge of their precise date was the discovery of a rich land Flora in some of the upper beds, next below the lower carboniferous rocks which overlie them unconformably. These fossil plants I was enabled to recognize as of the Devonian period, and the zealous researches, more especially of Mr. Hartt, have brought to light no less than forty to fifty species, or half of the whole number known in the Devonian, of Eastern America, as well as six species of insects, four of which have been described by Mr. Scudder.* These insects are the first ever found in rocks older than the carboniferous.

These rocks, consisting chiefly of hard shales and sandstones, having been ascertained to be Devonian, there still remained an im-

* Canadian Naturalist and Geologist, 1867.

mense thickness of underlying rocks of uncertain age. In the upper member of these rocks the same active observers already mentioned have discovered a rich primordial fauna, embracing species of *Conocephalites, Paradoxides, Microdiscus,* and *Agnostus,* as well as an *Orthis* and a new type of Cystidian. These fossils are regarded by Mr. Hartt and Mr. Billings, as of the age of Barrande's "Etage C," and as marking a new and older period of the "Silurian Primordial" than any other as yet recognized in America, with the exception of the slates holding *Paradoxides* in Massachusetts, and the similar slates of the "Older Slate Formation" of Jukes in Newfoundland. Descriptions of these fossils, by Mr. Hartt, will be published in the edition of Acadian geology now in press. It is proposed to call this series, represented in New Brunswick by the St. John slates, the *Acadian Series.*

Below these primordial beds are highly metamorphosed rocks, at least nine thousand feet in thickness, which have not afforded fossils. A portion of these beds, consisting principally of conglomerate and trappose beds, is regarded by Messrs. Matthew and Bailey as of the age of the Huronian. The remainder, containing much gneiss and a bed of crystalline limestone, they regard as Laurentian. If this view is correct, and it certainly seems to be probable, these rocks, thus rising through the oldest members of the lower silurian, and forming a stepping-stone between the Laurentian of Newfoundland and that of New Jersey, show that the foundations of the north-east and south-west line of the east side of North America were already laid in the Laurentian period. Still, it is not here, but farther west, that we are to look for the dividing line between the great inland silurian basin of America and that of the Atlantic coast, the latter, as has been pointed out by Prof. Hall and Sir W. E. Logan, so remarkably distinguished by the predominance of mechanical sediments, and by a development of the lower, rather than the upper members of the lower silurian.

To ascend from these rocks to the carboniferous: recent labors of Mr. Davidson, Mr. Hartt, and the author had led to the division of the lower carboniferous into successive subordinate stages, and to the determination of most of the marine fossils, and also to the explanation of the curious and apparently anomalous fact that some forms allied to Permian species actually exist in the lower carboniferous, under the productive coal measures. These researches had also shown that no distinction into sub-carboniferous and carboniferous proper can fairly be made in Nova Scotia, notwithstanding the grand development of the car-

boniferous in thickness. After noticing the large advances made in the fossil botany of Nova Scotia and New Brunswick, the paper referred to the discovery by Mr. Barnes of two new species of insects, and to the discovery by the writer of a new pulmonate mollusk described by Dr. P. P. Carpenter as *Conulus Priscus*. There are thus in the coal formation of Nova Scotia a *Pupa* and a *Conulus*, or *Zonites*, generically allied to living pulmonates, and representing already two of the principal types of these creatures.*

Specimens of these fossils were exhibited, and also specimens and a photograph of the Laurentian fossil *Eozoön Canadense*, more particularly mentioning the specimen recently found by the Canadian survey at Tudor, which shows this organism in a state of preservation comparable with that of ordinary silurian fossils.

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7. The Winooski Marble of Colchester, Vt. By C. H. Hitchcock, of New York, N. Y.

(abstract.)

The Winooski Marble Company hold a property of five hundred and ninety-six acres five miles distant from Burlington, upon which are exposures of a variegated marble well situated for working. The rock is a dolomite, containing twenty per cent. of silica, alumina, and iron. Some of the varieties exhibit nodules of calcite enclosing quartz, evidently formed like concretions. When present these small nodules render the stone harder to saw than the common marbles, rendering its cost about one third greater. The colors are various shades of red, chocolate, and brown, with patches, and irregular lines of white. These colors adapt the marbles to match with the modern style of furnishing houses better than the white and clouded varieties. Stones somewhat like this are common in Europe, but, being of jasper or porphyry, are very much more difficult to work. Slabs twelve feet long can be obtained of the Winooski marble, and of three feet or more in thickness. No work is now being done upon the property. The rock is of the same age with the red sandrock of Burlington, or the Lower Potsdam, at the base of the Lower Silurian. The slaty layers above are characterized by the presence of *Olenellus Thompsoni* and *O. Vermontana*.

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* Acadian Geology. Second edition.

8. The Geology of Vermont. By C. H. Hitchcock, of New York, N. Y.

(abstract.)

The Final Report upon the Geology of Vermont, published by the authority of the Legislature in 1861, contains all that was known of the rocks of the State down to that period. Since then the age of many of the groups has been determined more satisfactorily. The grouping of the formations upon my geological map in the Report, as "Upper Silurian" and "Mostly Devonian" were typographical errors. We should now employ the following schedule of rock formations in the State. These were exhibited upon a colored map of the size of the large map of Mr. Walling.

UNSTRATIFIED ROCKS.

Granite, syenite, protogine, with the traps and porphyries.

EOZOIC SYSTEM.

Laurentian gneiss of West Haven and the Green Mountain gneiss.

PALEOZOIC SYSTEM.

Lower Silurian.

1. Potsdam group — including the red sandrock, part of the "Hudson River" slates, part of the Georgia slate, most of the quartz rock, and the Potsdam sandstone of West Haven.
2. Calciferous sandrock.
3. Levis group, including the "Eolian limestones," "Hudson River" limestones, and the greater portion of the Georgia slate.
4. Lauzon group, including most of the "Talcose conglomerate," "Talcoid schists," and part of the Talcose schist.
5. Sillery group, the upper part of the Talcose schist. The Mica schist is 3, 4, or 5.
6. Chazy, Birdseye, and Black River limestones.
7. Trenton limestone.
8. Utica slate.

Upper Silurian.

1. Calciferous mica schist.
2. Clay slates of EastVermont (?)

Devonian.

Upper Helderberg limestone (?)

Cœnozoic.

Miocene, tertiary, and alluvium.

The Green Mountain gneiss enters the State from Massachusetts on the south and passes into Canada, following the course of the Green Mountains. Its gneissic character is often very obscure. Our sections give the formation an anticlinal structure, sometimes an overturn. In calling it Eozoic, we do not necessarily regard it as older than the Cambrian or Huronian. The following considerations render its Eozoic age probable.

1. The rock is on the line of the continuation of the Laurentian of New Jersey and Eastern New York, as confirmed by the recent observations of Sir W. E. Logan and Prof. James Hall. Between its known occurrence, in New Jersey, intervenes only the Hoosic Mountain range in Massachusetts and Connecticut. At one place the continuity of outcrop is interrupted by overlying limestones of the Levis group.

2. It exhibits generally an anticlinal structure. In Massachusetts, this may be observed at the Hoosic Tunnel. In Vermont upon sections Nos. 2, 4, 5, 9, 10, 10*a*, 11, and 13. In all the others the strata dip uniformly in one direction, and part of the formation must be inverted. According to the Canadian reports, in three sections across the continuation of the Green Mountains, "the strata have been observed to maintain dips generally at high angles in opposite directions from the axis of the mountain, with much constancy, for upwards of twenty-five miles."

The anticlinal structure is further proved by the repetition of the supposed Potsdam and Levis rocks upon both sides of the central gneiss, at Wallingford and Plymouth.

3. The Potsdam rocks flank the gneiss upon the west side as far north as Middlebury. If the gneiss were the sillery sandstone, as has been claimed, this quartz rock ought to belong to the Lauzon group.

But upon following the quartz rock northerly it is seen to terminate at Starksboro, near which termination it presents many of the characters of the red sandrock or Lower Potsdam, extending to Starksboro from Highgate. The quartz rock is probably the same with the red sandstone, as both are overlaid by the Levis limestone and resemble

each other much, near their supposed union. I find this view of the identity of those two formations confirmed by the late map of the Canadian survey, published in 1866.

4. A conglomerate at the base of the Potsdam (quartz rock) contains pebbles derived from the gneissic rocks. At the western border of the gneiss there appears in Stamford, Sunderland, and Ripton a peculiar granite whose constituent quartz is blue, and I have seen nowhere else a granite of this character. The conglomerate with pebbles of blue quartz has been observed at Sunderland, E. Wallingford, Pittsford, and in boulders about Rutland. The Wallingford rock contains also pebbles of gneiss. These examples appear to prove that the granite existed before the deposition of the Potsdam, and if older, it is probably Eozoic. A conglomerate perhaps of the Lauzon group, in Lincoln, also contains pebbles of blue quartz.

By recent observations the members of the so-called Taconic system appear to be of lower silurian age. By following their distribution northerly, the probable equivalency of the various members may be made out. The typical localities for this system were largely in the south part of the State. The "Granular Quartz," by our observations, appears to belong to the Potsdam group; the "Stockbridge limestones" (Eolian) belong to the Levis or Philipsburg limestones; the "magnesian slate," to the Lauzon group; the "Taconic" and "Roofing slate," in part to the Levis and in part to the Potsdam series. The "Black slate" seems to have been properly located beneath the ordinary Potsdam sandstone. Thus as the system is chiefly Lower Silurian in character, it does not seem best to retain the name of Taconic for that portion which alone belongs to the position assigned by Prof. Emmons. The reference of trilobites like *Olenus* and *Paradoxides* to a system of rocks older than those containing *Asaphus* and *Trinucleus* was first made by Emmons. Hence although he insists that the red sandrock of Vermont is newer than Taconic, if the name be retained, it should be applied to the formations called locally the St. Johns groups of Newfoundland and New Brunswick, the Braintree slates of Massachusetts, and the Lower Potsdam of Vermont. In no case, however, can a Taconic group be legitimately correlated with the Huronian of America or the Cambrian of Europe. It should, on paleontological grounds, be regarded as a subordinate part of the Lower Silurian system. The few simple fossils of the Cambrian ally it with the Laurentian under the general designation of Eozoic.

9. Explanation of a Geological Map of Maine. By C. H. Hitchcock, of New York, N. Y.

(abstract.)

The results obtained during the progress of the Maine Scientific Survey in 1861, 1862, have been embodied in a large map, the property of the Legislature. By the permission of the executive officers of that State, the map was exhibited to the Association. Gneissic rocks with granite and patches of schist and limestones, occupy the hilly parts of York, Cumberland, and Oxford Counties. This is the remotest extension of the White Mountain series. The same appear in great amount along the coast, including the area twenty miles back, between Portland and the Penobscot River. Between those gneissic masses commences a mica schist, extending north-easterly into New Brunswick. Where it crosses the Penobscot River, it occupies the area between Medway and Bucksport. At the eastern State line it is narrower, including Orient, Amity, and part of Hodgdon. In Hancock County, a range of granite commences at Mount Desert Island and extends north-easterly, entering New Brunswick with the entire width of the Eastern Schoodic Lakes. Another development of mica schist appears on the south of the granite, followed in the south-east part of Washington County by smaller deposits of flinty slates, the Lower Helderberg, Upper Devonian, and by great masses of trappean rocks.

The northern part of the State is sparsely settled, and it is not everywhere easy to trace out the strata. But it is in this section that the greatest number of fossils are found. A wide formation of clay slate succeeds to the great central belt of mica schist. One like it reappears on the Lower Alleguash waters and the St. John River above the Great Falls. This is also underlaid by the Quebec group along the Canadian border. The northern part of the State, from the distribution of these two groups, would appear to form a great synclinal basin, holding at various parts of its surface a long area of Oriskany sandstone, Cauda-Galli grit, and various fossiliferous Upper Silurian and Devonian strata. The clay slates about Waterville contain fine examples of *Nereites* and *Myrianites*. The Port Daniel limestone of Lake Sedgwick has afforded a fine series of trilobites and brachiopods. The surface geology of Maine is remarkably interesting. Examples of local glaciers, and thirty-four "eskers," or "horsebacks," have been described. The chief exports of mineral wealth are granite and lime.

10. The Distortion and Metamorphosis of Pebbles in Conglomerates. By C. H. Hitchcock, of New York, N. Y.

(abstract.)

At the Newport meeting of this Association I presented many facts relating to the distortion of pebbles in the conglomerate near that city, under the title, "Geology of the Island of Aquidneck." Since that time my father has described other localities, in his Final Report upon the Geology of Vermont, where he takes the ground that conglomerates may become altered into schists so completely that the original structure will be obliterated. I have treated of the same subject fully in my Preliminary Report upon the Geology of Maine, 1861, and in my two reports upon the geology of that State have described four new localities, one of which, in Sandy River Plantation, exhibits the phenomenon of distortion in great perfection. All these matters were fully treated in the paper read before the Association, but I will present for publication only some facts on this subject obtained from European authorities.

There are other phenomena analogous to the distortion of pebbles. First, I refer to the distortion of fossils. No better illustration can be given than the grotesque and varied forms of the trilobite, *Angelina Sedgwicki*. Some have lain across, some along, and some oblique to the clearage of the slate, and a compressing force has distorted them, so that it is rare to find one showing the normal shape.

Secondly, the microscopic examination of slates has shown an elongation and flattening of particles within them. Tyndall refers to two examples, the German razor stone and the greenish spots in writing slates.

In the Royal Museum of Economic Geology at Jermyn Street, London, are two examples of the distortion of pebbles by pressure. The first is a collection made by Mr. Salter of quartz stones, "which have been subjected to enormous pressure in the neighborhood of a fault. These rigid pebbles have, in some cases, been squeezed against each other so as produce mutual flattening and indentation. Some of them have yielded along planes passing through them, as if one-half had slidden over the other; but the reattachment is very strong. Some of the larger stones, moreover, which have endured pressure at

a particular point are fissured radially around this point." The other example is of stones in a Permian conglomerate, and the following is Prof. Ramsay's description of them. The "component stones are often from three to nine inches in diameter, and where they touch in the rock they are not scratched, but indent each other at the points of contact; the indentations being due to the fact that, while those gravels were still incoherent, over great areas, the upper parts of the New Red Series, the Lias, and perhaps other newer strata, were piled upon them, and the vertical pressure consequent on this vast superincumbent pile induced a lateral pressure in the loose-lying pebbles of the conglomerate; so that being squeezed, not only downwards, but outwards, they ground on each other, and, perhaps partly by the aid of intervening grains of sand, circular indentations were formed sometimes an inch in diameter. Some of them are fractured and re-cemented. The fractures were produced by pressure, generally close to faults."

Very recently H. C. Sorby, Esq., F. R. S., of Sheffield, England, has made an important suggestion upon the mutual interpenetration of pebbles of limestone in the conglomerate of the Nagelflue in Switzerland, which enables him to account for the phenomena without invoking the aid of plasticity. The case seems to be one where there is simply an indentation, without elongation or flattening. We doubt whether the phenomena observed in America can be explained without plasticity, but desire to adopt the principle, and explain all the appearances by it, if possible.

Mr. Sorby writes, "All previous writers had attempted to explain the impressions in the pebbles either by mere mechanical or simple chemical action, localized by mechanical conditions. The facts point so strongly to both agencies, that it is easy to understand why the opinions ever varied between the two extremes; and it now appears to me astonishing that no one was led at an earlier period to suggest a correlated action of both. At the same time we must admit that a large part of those who have studied the question did so before the doctrines of the correlation and conservation of force were generally admitted or understood. It is mainly as an illustration of the applicability of such principles to geology that I have been led to draw attention to the impressed pebbles.

"In the case of the majority of substances mechanical pressure increases their solubility. For example, if a crystal of common salt

is placed in a perfectly concentrated solution, so that no more would be dissolved under the ordinary pressure, on applying to the solution a pressure of, for example, a thousand pounds to the square inch, and maintaining it for a sufficiently long time, more salt is dissolved, and is again deposited on removing the pressure. I also found that a glass rod with a small, round termination, pressed with a force of ten pounds against a plate of rock salt, had, in the course of a year, produced a well-marked depression, surrounded by a ring of small crystals raised above the level of the original surface. The salt had been exposed to the atmosphere, in which case a thin film of moisture is generally present on the surface; and, since the force of capillary attraction varies inversely as the width between two plates, where the salt was in almost absolute contact with the glass, the force with which the liquid would penetrate between them would be very great. It therefore appears to me nearly certain that the pressure would be, to a considerable extent, sustained by a thin film of liquid, which, being thus under pressure, would dissolve more salt than the rest of the solution, and, by slow diffusion amongst it, the salt would thus be transferred from where the pressure is greatest to where it is less.

"Now these experimental results entirely satisfy the conditions met with in the case of the impressed limestone pebbles. Pressed one against the other with great force, at a considerable depth below the surface of the earth, and surrounded with water saturated with carbonate of lime, in accordance with the principles I have described, the limestone would dissolve, so that in time one pebble would penetrate into the other, and carbonate of lime would be deposited in a crystalline form elsewhere, where the pressure was less. This explanation agrees admirably with the various facts. The structure of the limestone proves most conclusively that the depressions were produced by actual removal of material, and not by its yielding as a plastic substance. Moreover, it is only the carbonate of line which has been removed, — only the soluble part of the pebble, — the insoluble earthy portion having been left behind at the bottom of the depressions; and therefore the removal cannot have been effected by mere mechanical means, which would have removed the whole indiscriminately. I attribute the solution of the material of one of the pebbles, and the unaltered outline of the other, to a difference in their hardness, or the amount of earthy or sandy impurities; whilst, at the same time, I think it probable that a difference in curvature may have considerable influence."

There has been a large number of communications upon the indentation and alteration of pebbles in Europe. The earliest were noticed in the Jahrbuch für Mineralogie for 1836 and 1843 by Lortel; in 1840 by Blum; in 1841 and 1848 by Escher von der Linth, etc.

The first notice of them in this country was in my father's Report upon the Geology of Massachusetts in 1833. Hence we may claim for an American writer the credit of having first brought the attention of the scientific world to this subject.

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11. Tracts of Ancient Glaciers in the White Mountains of New Hampshire, with a few remarks upon the geological Structure of some Portions of that Group. By George L. Vose, of Paris Hill, Maine.

It was stated in this paper, that while the general direction of glacial action in the western part of Maine is from north and north-west to south and south-east, the furrows upon the rocks, in that part of the Androscoggin valley, extending from Gorham, in New Hampshire, to Bethel, in Maine, and which has a course from west to east, varied from S. 20° E., to S. 80° E.; and that, while the furrows in the depressions between the higher summits of the main chain of the White Mountains point to the north and north-west, those in the Peabody valley range from N. 30° E. to N. 40° E., thus according with the general direction of that valley, and being nearly at right angles with the furrows in the valley of the Androscoggin. It was thus inferred that in addition to the general movement of ice over this district, from north and north-west to south and south-east, there have been local glaciers which were confined to the valleys of the Peabody and Androscoggin Rivers.

It was farther stated that the whole surface geology of the district upon the west of the White Mountains, from Fabyan's to the Notch, furnished, in various forms of modified drift, plain evidence of the action of large bodies of water at a very recent period; but that whether this locality, now two thousand feet above the sea, had been covered by the ocean, or by bodies of fresh water, retained by some barriers not now existing, was not determined.

Regarding the arrangement of the great central mass of rocks

forming the main chain of the White Mountains, it was stated that this portion of the group appeared to have neither the anticlinal build of the older geologists, nor yet the regular synclinal build more recently suggested; but that the top of Mount Adams, of Mount Jefferson, of Mount Clay, and the section from Tuckerman's Ravine through the Lake of the Clouds, all seemed to show a prevalent steep dip to the north and north-west; and it was suggested that the main chain of the White Mountains was formed by a fragment of the western slope of an immense anticlinal wave, of which the crest would have been over the Peabody valley, and of which perhaps a fragment of the eastern slope may be found in the opposite and parallel range of the Carter Mountains; in which case the Peabody valley would be a valley of denudation.

The feature so common in the relief of these mountains, the long, gentle, northern slope, and the abrupt southern descent, was considered to be due more to the position and direction of the bedding of the rocks than to the movement of ice from north to south over these summits; although it was believed that the latter operation played an important part in the rounding off of these mountains.

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12. The Red Sandstone of Vermont and its Relations. By John P. Perry, of Cambridge, Mass.

The representations made of the red sandstone of Vermont, at different times and in various places, have been exceedingly discordant. Indeed, in not a few cases, the views entertained and exhibited, respecting this formation, have been diametrically opposed.

Presuming that the rocky beds themselves have a story to tell, it may be desirable for us to put them on the stand, and apply to them the most crucial tests in our power.

As the Association for the Advancement of Science is now convened in the vicinity of these rocks, it will be easy, for such of its members as desire, to subject, if they have not already done so, and if they have, to re-subject, this fragment of the Old Book of Nature to a personal examination. As a help in this direction, let us raise a few queries in regard to the formation, and endeavor to answer them by an appeal to facts.

I. And, in the first place, we may ask, What is the Red Sandstone of Vermont?

With the exception of the late Dr. Emmons, who long ago described this rock as Potsdam sandstone, it has been, up to a very recent day, quite generally regarded as belonging to the Medina formation of the New York geologists.

The rock itself is a narrow band of sandstone, usually red, sometimes gray, and often calcareous, lying in the lower portion of the Champlain slope of Vermont, and dipping gently to the east. It has been much eroded, what remains seeming to be only a small part of the original formation.

As early as 1847, Prof. Thompson discovered fragments of trilobites in a portion of the band situated in Highgate. These failed, however, to attract much attention, and thus the real age of the rock remained, if not undetermined, at least, for the most part, unrecognized.

The remains of two or three species of fossils were collected by Dr. G. M. Hall and myself at this locality, at various times between 1855 and '60. On my showing several glabellæ of these fossil trilobites to E. Billings, Esq., early in the summer of 1861, he at once remarked, "They are *Conocephalites*, and the rock must be Potsdam sandstone."

Without stopping to mention the different individuals * who have engaged with praiseworthy zeal in the study of this formation, I may simply add that, since 1861, the rock has come to be very generally, if not universally, recognized as belonging to the horizon of the Potsdam sandstone.

II. We may next ask whether this sandstone be succeeded on the east by newer formations, that have been disguised by metamorphic action?

It was for a long time, and I suppose is still asserted, that this rock underlies more recent formations on the east, probably of Silurian and Devonian age; and that the latter, having been subjected to intense heat, have been so transformed as to be scarcely recognized in

* It would give me great pleasure to refer in particular to the late Dr. Emmons, to the late Profs. Adams and Thompson, to the late President Hitchcock and his associates in the Geological Survey of Vermont, to Sir William Logan and E. Billings, Esq., of the Canada Survey, and last, but by no means least, to Prof. Marcou, as gentlemen by whose labors I have been not a little assisted, in various ways, in my study of the rocks of Western Vermont.

their new character; in short, that all the so-called Taconic rocks, as described by Dr. Emmons, are later than the red sandstone.

Without dwelling on the fact that these more easterly rocks do not ordinarily exhibit such marks of metamorphism as the theory implies, and that careful search has shown that some of the Taconic rocks are not a little fossiliferous, I would insist, in the first place, that the Red Sandstone does not pass under as the dip might seem to suggest, but simply rests against the so-called newer formations on the east. This may be seen in Swanton, where the Potsdam band has been cut through, the excavated valleys thus affording exposures of the underlying rocks as they occasionally crop out, as well as of the overlying sandstone.

But more than this: the red sandstone, in several instances, extends over almost the entire, if not over the whole, width of the Taconic series. This superposition is well exhibited in the counties of Addison and Chittenden, where the Potsdam formation stretches from Charlotte and Ferrisburg eastward to Starksboro, overlying nearly, if not quite, all the Taconic rocks, which occasionally crop out, and may be readily recognized by a practised eye. Something very similar is observable in Franklin County; also, as I think, in the extension of the same range into Canada.

Some, however, may be disposed to urge that there has been an overturn, and that thus the Potsdam formation, though really older than the Taconic strata, usually lies above them. If reference be made to partial or local inversions, it may be said that nothing of this kind, so far as I can judge, is adequate to account for the position of the rocks at the localities already cited; indeed, the two series of beds sustain substantially the same relations to each other through the entire length of the State. If, on the other hand, appeal be made to a general overturn, it is right to demand the proof. This I have never been able to get. In fact, of such an overturn I have been unable, after years of search, to discover the slightest evidence, or the faintest trace. On the north-west side of Snake Mountain, in Addison, the base of the sandstone is found so resting on the underlying slate as to show that the present is substantially its original position. Similar evidence reveals itself at Lone Rock Point, in Burlington, at Mallet's Bay, in Colchester, and at other localities. And then it may be added, that the beds would have been more broken in case of an inversion, and that layers of rock containing rain-drop impressions are found in their normal position.

The theory of metamorphism, therefore, so far as invoked in the present case, seems to fall to the ground, while facts generally, so far as I have been able to find them having a bearing on the subject, decidedly testify that the red sandstone does not extend under metamorphic formations on the east.

III. Again, let us inquire whether the sedimentary beds which underlie the red sandstone be an extension of the Potsdam formation downward?

The gray siliceous rocks at Potsdam, N. Y., have been, for the most part, regarded as the lowest portion of the sedimentary strata. When, therefore, it became certain that the red sandstone of Vermont must be referred to the same horizon, it was soon assumed that the underlying, fossil-bearing slates must be considered as a downward extension of the Potsdam sandstone. Whether this assumption be correct or not is to be determined by the import of the latter term. The word "Potsdam," in its earliest geologic sense, refers to the just mentioned sedimentary rocks in the township of that name. It also applies, by legitimate extension, to all rocky beds elsewhere found of the same specific life-period. Accordingly, to belong to this series of deposits, a formation must either exactly answer in age to the beds of sandstone at Potsdam, or else be a conformable extension, upward or downward, of rocks identical with them in the time of their deposition.

How is it now with the sedimentary strata before us? In the first place, the slates underlying the red sandstone of Vermont do not conform with it in dip. The variation referred to may be seen at Snake Mountain, in Addison County; in Charlotte, Shelburn, Burlington, and Colchester, in Chittendon County; also in St. Albans, Swanton, and Highgate, in Franklin County, as well as in other places.

Again, there is a lack of conformity in the strike of the sandstone, and that of the underlying slates. This fact may be observed at the several localities just mentioned, as well as by a glance at the representation given on the Geological Map, published in the "Final Report," on the Geology of the State.

Once again, it should be remarked that there is a lack of conformity in the organic remains. Without enumerating the several fossils, I would simply remark that all the vegetable and animal remains, thus far brought to light in these respective groups of Vermont strata, are specifically distinct. Indeed, no species is yet known to have been

discovered, either in this State or elsewhere, common to the two systems of rocks, and therefore nothing to indicate that they are of the same life-period.

It should accordingly seem, from this threefold lack of conformity, that the beds underlying the red sandstone are distinct from it, and cannot be, with any propriety, either referred to the formation, or regarded as belonging to the period called Potsdam.

IV. What relation, then, we may now ask, does the red sandstone sustain to the underlying formations?

The true answer to this query must depend upon the determination of the age of the inferior rocks. These were long and generally, though by no means universally, regarded as Utica slate and Lorrain shale. They should be divided, as is most probable, into two parts, and may be locally designated as Black, or Swanton slate, and Brown or Georgia slate. That they are not of so late an age as the Utica and Lorrain beds is apparent from what has been said of the red sandstone which overlies them. In some cases, also, the Swanton slates may be seen beneath the Potsdam formation, not only along its western, but also near its eastern limits. So the Georgia slate may be shown in some places, as in Swanton, to underlie the Potsdam sandstone in its extreme extension eastward. These facts, it is thought, entirely meet the supposition sometimes made, that the underlying slate is Utica, the Potsdam beds having been pushed westward, and thus made to overlap it; for there is abundant evidence that the so-called lateral movement was, at the best, very slight.

While, then, the underlying beds cannot be regarded as Utica slate, or Lorrain shale, while they are also older than the Potsdam formation, we may well ask what their organic remains teach us. It is this: that these slates clearly answer to the Primordial Zone of Barrande. The fossils are plainly primordial in type.

And what do the fossils of the red sandstone teach us? They likewise unmistakably belong to the Primordial Zone of Life, and thus show that the sandstone is primordial. But they not only form a part of the first grand type of life, they are also specifically distinct from those of the underlying slates, and a trifle later in the geologic sense of the term. In this wise they indicate the relative age of the Potsdam sandstone.

This being the state of the case, it must be clear that, while the underlying and the overlying beds are discordant in dip, in strike and

included fossil remains, they are yet nearly related; that they both should be regarded as belonging to one and the same great zone of living existence; that the red sandstone accordingly claims recognition, and must, of good right, be recognized as an upper division of the Tatonic or Primordial System of rocks: nay, more, that it follows the inferior groups, after a short break in time and a slight interruption in the organic succession, and seems to cap them with the more mature forms of the same grand type of life.

V. We may, accordingly ask, as a final question, whether the red sandstone properly belong to the Lower Silurian System of rocks?

The Potsdam formation has been almost universally counted as the base of the Champlain, or Lower Silurian beds of New York. And this determination of the mass was very natural, especially at the time and place at which it was originally made; for no fossil-bearing strata were then known to be older; while at the typical locality the formation in question rests directly upon rocks usually called igneous, and is, in many localities, succeeded by the calciferous sandrock.

It seems to be a fact, however, that the Potsdam sandstone and the calciferous sandrock are stratigraphically unconformable. This discordance may be seen at Chazy, N. Y., while the relations generally of the two formations may be well observed at Whitehall, N. Y., and West Haven, Vt.

These groups of rocks, moreover, are seen to be unconformable when looked at palæontologically. Indeed, there is an almost total break in the sequence of life between the two formations. Still this point alone is not enough; it is only negative. It will have greatly increased force, if it can be connected with positive testimony.

And there is additional evidence of a positive kind. A different and an advanced zone of life seems to commence with this higher formation. The characteristic primordial forms disappear almost entirely with the Potsdam, while a new and what should be perhaps called the second great chronological type of existence makes its appearance in the calciferous. Thus looked at under the relations of time, there is seen to be a marked difference in the two formations. The types of life are clearly distinct.

These facts, accordingly, seem to indicate that the Potsdam sandstone is not correctly described, and cannot be properly viewed as the lowest member of the second great group of fossiliferous strata; that of good right it should be regarded as the summit, or crowning portion

of the Primordial Zone of Life; and that thus the calciferous formation both presents itself in nature, and in consequence claims recognition as the true base of the Champlain, or Lower Silurian System of rocks.

Having thus cursorily surveyed the red sandstone of Vermont, as it is in itself, and in its more general relations, I will close this paper with a brief synopsis of the two great systems of rocks, which have been under review. Reading from below upward, we have

II. Champlain
3. Upper: — Birdseye, Black River, Trenton, Utica, and Lorrain.
2. Middle: — Chazy, in its several divisions.
1. Lower: — Calciferous, in its several divisions.

I. Taconic
3. Upper: — Potsdam, in its several divisions.
2. Middle: — Black and Brown Slates with Limestones and Sandstones.
1. Lower: — Talcose and talcoid Slates with Limestones and Quartzites (or Conglomerates.)

The above is given as the most satisfactory general view that I have been able, up to this time, to get of these rocks, after a long study of them in the field. And it is presented, not as an ultimatum, but simply as an essay toward the solution of some of the manifold difficulties involved in one of the most intricate and perplexing sections of the Geologic Record; presented with diffidence, and still with unwavering confidence in the truth of nature; presented in the hope that new light may be elicited, that old errors, so far as they exist, may be discarded, and that thus a more consistent understanding of these formations may be at last secured.

In this summary, the terms "Taconic" and "Champlain" are used, not as implying any theory, but because they are familiar and local. Insomuch as they were introduced long ago, are simple, short, and convenient, as well as locally descriptive, — also, as commemorative of the honored dead, — I see many good reasons for retaining, and no occasion for discarding them.

13. On the Origin of the so-called Lignilites or Epsomites. By O. C. Marsh, of New Haven, Conn.

(abstract.)

The peculiar jointed or columnar structure, which in various formations often unites the adjoining surfaces of two layers of limestone, has long been a puzzle to geologists, and many attempts have been made to solve the mystery of its origin. Indications of this structure may be detected in nearly all limestones, but only under peculiar circumstances is it developed in its full perfection. Probably the finest illustrations of it in Europe are to be seen in the Muschelkalk of Germany, where it appears to have first attracted attention. In this country, the Clinton limestone, of Niagara County, N. Y., affords, perhaps, the most perfect specimens, as well as the best field for investigating the subject.

An examination of this structure, as it usually occurs *in situ*, shows a series of columnar markings and separate columns passing off at right angles from a seam between two beds of limestone or calcareous shale. The individual columns vary from one half to four inches in length, and one fourth to two inches in diameter, although they are sometimes much larger. In nearly all instances they pass from the lower layer into the one above, but rarely the reverse takes place. The sides of the columns are always marked with longitudinal groovings or striæ, and their free ends are usually covered with a rounded or pointed cap of clay. In the older rocks this clay covering has become hard, and is firmly attached to the column. At some localities the more perfect columns have a fossil shell or other organic substance on their summit beneath the clay. The columns themselves are of precisely the same material as the surrounding rock, although not unfrequently they are coated externally with some foreign substance. Occasionally the structure takes the form of irregular jointed seams, reminding one of the sutures of the human cranium. At a few localities suture joints have been observed cutting the planes of stratification more or less obliquely, or even at right angles.

The limits of the present paper forbid more than a brief mention of the more important theories that have been proposed to account for the origin of this peculiar structure. In this country it appears to

have been first described by Eaton, in 1824, who considered the columns fossil corals, and applied to them the name of *lignilites*.* In 1831, Bonnycastle described a number of specimens, and was inclined to regard them, not as fossils, but as a new mineral due to infiltration.† A few years later Vanuxem claimed to have solved the mystery. The columns, he thought, were due to the crystallization of sulphate of magnesia, and he therefore gave them the name of *Epsomites*, by which they have since been most generally known in this country.‡ Prof. Hall, in his final Report, accepted this explanation, but suggested that the columns might, in some cases, be due to the crystallization of carbonate of lime.§ Prof. Emmons, also, in his Report, expressed the opinion that in one instance sulphate of strontia might have been the crystallizing agent.‖ Finally, in the General Report on the Geology of Canada, the nature and occurrence of this structure is discussed at some length by Dr. Hunt. The name *Crystallites* is used for the columns, and the suggestion is made that the "crystals may have been sulphate of soda, rather than a magnesia salt."¶ Views similar to those specified have been expressed also in several other works of acknowledged authority. That crystallization in some form was the cause of the structure seems to have been very generally accepted in this country up to the present time.

In Europe, especially on the continent, this question has attracted much more attention, and many and various attempts have been made to find a satisfactory solution of the difficulty. Early in the present century geologists there were already familiar with the structure. The first author, however, who made a special study of it was, was Klöden, of Berlin, who in 1828 gave a description of the forms that he had observed in the Muschelkalk at Rüdersdorf. He regarded the columns as fossils; and, although in doubt as to the nature of the supposed animal, proposed for it the name *Stylolites Sulcatus*.** A few years later he discussed the subject much more fully, and gave excellent

* Report on the District adjoining the Erie Canal, p. 134.

† Silliman's Journal, Vol. XX., p. 74.

‡ Second Annual Report on Geology of N. Y., p. 271, 1838, and Final Report p. 107, 1842.

§ Report on 4th District of N. Y., p. 96.

‖ Report on 2d District of N. Y., p. 111.

¶ Geology of Canada, p. 632, 1863.

** Beitrage zur Min. u. Geol. Kenntniss der Mark Brandenburg, I. p. 58.

figures of the principal forms he had met with.* The name *Stylolites*† has since been generally used in Germany for these forms, and no other appears to have been employed in other parts of Europe. As it has priority, and involves no theory, it should be universally adopted. The next careful investigation of the structure was by Quenstedt, who in 1837 published an important paper on the subject.‡ Having observed that some of the more perfect columns were capped with fossil shells, he came to the conclusion that Stylolites were merely segregations, which owed their shape and origin to fossils lying in the soft mass of limestone during consolidation. Huot, in 1842, described specimens of this structure from the Jurassic of the Crimea, and expressed the opinion that they were due to crystallization and aggregation.§ Cotta, in a work published in 1846, compared Stylolites with the ice crystals that form in the soil in winter, and inferred for both a similar origin.‖ In 1852, Plieninger proposed an original and elaborate explanation, which, notwithstanding its improbability, has since found quite a number of supporters.¶ He supposed that the surface of the soft limestone was first raised above the water, and on drying became separated into blocks by shrinkage-cracks. Through the action of rain, these were reduced in size, and the columns, protected by shells and other foreign substances, were thus made to assume definite forms. After subsidence, another layer was deposited over this surface, and the whole gradually became compact limestone. The fact that rain, under certain circumstances, may produce columns very similar in form to Stylolites had already been noticed, and this was doubtless one reason why Plieninger's theory gained so many adherents, one of whom appears to have been Quenstedt,** who had himself long before so nearly cleared up the mystery. In a later work however, he presents again his original explanation with some modifications, which make it, although still crude and incomplete, much more satisfactory than any previously offered.†† Von Alberti, in 1858, suggested still another

* Versteinerungen der Mark Brandenburg, p. 288. Berlin, 1831.

† From στυλος, a column.

‡ Wiegmann's Archiv., V. p. 137, also Jahrbuch der Mineralogie etc., p. 496, 1837.

§ Voyage dans la Russie merid. II. p. 369.

‖ Grundriss der Geologie, p. 128.

¶ Würtemberg. Naturwissenschaft. Jahresheften, B. VIII. p. 78.

** Petrefacten Kunde, p. 505.

†† Epochen der Natur, p. 198.

hypothesis. Having observed Stylolites covered with a dark substance which he regarded as bitumen, he expressed the opinion that the columns were formed by drops of petroleum pushing their way upward through the soft rock.* One of the latest writers on the subject is Von Meyer, who claims that Stylolites are due to the crystallization of gypsum, as he had detected columns coated with that substance.†

This brief synopsis of the most important literature on this subject is sufficient to show that the question under consideration is one of no little interest. It will, moreover, be at once evident to any one who has made a careful study of Stylolites that many of the explanations proposed are based on merely local peculiarities, or unessential features of the structure; and hence, even if true in the instances cited, would not account for it elsewhere. A comparison, however, of the various forms of this structure, as they occur in different formations, and at widely separated localities, clearly shows that all have been produced by some common cause, which was not dependent on local influences or conditions. The subject of the present paper was to prove that this structure in all its various modifications was simply the result of *pressure*. The author had carefully examined many typical localities in this country and in Europe, and found at each conclusive evidence in favor of this explanation, which satisfactorily accounts for all the known phenomena of the structure.

If any characteristic locality of Stylolites be examined with care, it will readily be seen that a displacement took place in the rock before consolidation was completed. It will, moreover, not be difficult to perceive that when the columns stand at right angles to the stratification, they have been produced by vertical pressure, resulting from the weight of the superincumbent strata; and that the comparatively few suture joints having a different position are due to lateral pressure.

Although all the separate columns show indications of having been thus made by pressure, this origin becomes unmistakable if we examine the more perfect ones, especially those from a homogeneous, fossiliferous limestone, such e. g. as the Muschelkalk of Northern Germany, or the Clinton limestone at Lockport, and other points in Western New York. When the Stylolites are well developed in such a rock, it will generally be found that the columns start from the junction of two beds of limestone, separated by a thin seam of argillaceous shale.

* Würtemberg. Naturwissenschaft. Jahresheften, p. 292.

† Neues Jahrbuch für Mineralogie etc., 1862, p. 590.

Nearly all the separate columns, moreover, have on their summits *a fossil shell, or the inorganic substance, which has accurately determined their shape*, and above this a rounded or pointed cap of shale, evidently identical with the layer already mentioned, and separated from it when the strata settled during consolidation. The longer columns will usually have the convex side of the shell uppermost, and the shorter columns the reverse. When the shell lies obliquely on the column, the latter will, in most cases, be found curved, the degree of obliquity of the shell clearly determining the amount of curvature.

From these and other similar facts it will not be difficult to ascertain how these striated and capped columns were formed, although the mystery could scarcely have been solved from a study of imperfect Stylolites, such as occur in most formations. Let us first suppose a quantity of fine carbonate of lime, sufficient when consolidated to make a thick bed of limestone, slowly deposited under water; and, while still, soft shells and other organic substances scattered over it, and the whole then covered with a very thin layer of argillaceous mud. If, after this, the deposition of calcareous matter proceeds, gradually forming a second bed, its increasing weight will slowly condense the bed below. The shells beneath the clay layer will offer more resistance to the vertical pressure than the material around them, and hence the latter will be carried downward more rapidly, thus leaving columns projecting into the bed above, each protected by its covering, and taking its exact shape from its outline. That this must have been essentially the method of formation, every typical locality of Stylolites, if carefully studied, will afford ample evidence.

The immediate cause of the formation of columns under the above circumstances is clearly a difference of resistance to the pressure between the shell, supported by the material beneath it, and the surrounding mass. The reason why the shell resists the pressure more effectually than the substance around it may be owing, first, to its form, which, when its convex side is upward, enables it to act as a wedge, thus overcoming in part the cohesion of the material above it; secondly, to its weight, which would slightly condense the plastic mass beneath it, and thus secure a more firm support; or, thirdly, to its being an organic substance, which, like the nucleus of a concretion, has attracted to itself and consolidated the particles of carbonate of lime beneath it, but not those above, owing to the intervening argillaceous layer. Any one of these causes would, doubtless, be sufficient

to produce the superior density required to start a column, and this would at once have its farther progress facilitated by a cap of mud formed above the shell, thus rendering the summit of the column more convex, and hence diminishing the effective pressure. If, however, the concave side of the shell be uppermost, this assistance is in a measure lost, as the cavity of the shell must first be filled from the argillaceous layer before the column can secure a convex summit. Hence such columns are usually shorter than those which have the shell reversed.

If the shell, instead of lying horizontal, as in the above instances, has an oblique position, curved columns will generally be formed, the curvature being toward the upper edge of the shell, and its amount depending upon the degree of elevation. Where the rock is not homogeneous, bent or even broken columns often occur, evidently caused by meeting with impediments, just as a nail is turned from its course when driven against an obstacle. To carry out the simile, the columns with the oblique shells curve towards the sharp edge of the summit exactly as a horseshoe nail bends outward when driven into the hoof, and for precisely the same reason.

The comparatively few Stylolites extending from the upper layer of limestone into the lower are evidently formed in essentially the same way as those already described, although under somewhat different circumstances. Where the shape has been determined by a fossil, it will generally be found that this was deposited above the argillaceous layer rather than below it. The cause of the superior density required will readily be inferred from what has been stated above.

The foregoing explanation has been mainly suggested by a study of the more perfect, separate columns, which usually appear to be formed under essentially the circumstances already mentioned. Where, however, the conditions are less favorable, columns and elevations, more or less regular in shape, may still be formed, and such alone are to be found at most localities. To this class clearly belong the specimens described hitherto by the distinguished geologists who have investigated the subject in this country, and the same holds true, almost without exception, of those examined by foreign authors. Such specimens, viewed in the light of the more perfect columns, often show indications of their origin from pressure; but as the crowning shell — the key to the mystery — is wanting, they alone would hardly reveal the mode of their formation, and hence it is by no means strange that their unessential features should have been made the basis of so many theories of explanation.

The oblique suture joints, already alluded to, are clearly due to the same general cause as the more perfect Stylolites. Those that cut the strata at a high angle evidently owe their origin to lateral pressure, acting along a plane of fracture, and thus driving into each other the irregular adjoining surfaces. Such joints are not uncommon in the water-line of Monroe County, N. Y., and a characteristic example is figured in Prof. Hall's final Report.* The same rock contains an abundance of imperfect columnar Stylolites, such as usually occur in a homogeneous nonfossiliferous limestone.

In addition to the varieties of Stylolites already mentioned, many others may be found at nearly every typical locality. Not merely foreign substances alone, but even any inequality in the density of the plastic strata will prevent a perfectly uniform settling of the whole, and also accurately register the amount of interference thus occasioned. In this way striæ and rude indications of columns are often formed along seams, or even in the body of the limestone itself. So also where the argillaceous layer is thick, and the limestone not homogeneous, rounded elevations and depressions will be formed along the planes of junction. Examples of this are common in the Trenton as well as in the corniferous limestones of New York.

Where concretions are imbedded in shale, as in the Hamilton group of Western New York, their sides will not unfrequently be found striated like the sides of Stylolites, clearly due to the sliding motion of the surrounding rock. When this takes place before the concretions are fully completed, very peculiar forms are often produced. Where the strata of shale themselves have been disturbed and distorted before consolidation was entirely finished, they are often fractured in various directions, and the adjoining surfaces of the fragments finely polished by the pressure of the disturbing force. Examples of this may be seen in the Hudson River slates at Cohoes, N. Y., and at other points on the Mohawk. Where the rock becomes nearly or quite solid before fracture, the well-known "Slickensides" are formed, which every one admits are merely friction-marks, due to the pressure or motion of adjoining surfaces, as their mode of formation may often be detected while still in progress. Such examples, however, constitute one end of a series extending with many intermediate gradations through the forms just described up to the perfect columns of the Stylolites with

* Geology of N. Y., Fourth District, p. 131.

their characteristic covering, all clearly owing their origin to one common and simple cause.* The series might, perhaps, be extended even farther, so as to include the structure known as "Cone-in-Cone," which, according to the investigations of the author, is probably due to the action of pressure on concretionary structure when in process of formation. Intermediate forms between Stylolites and Cone-in-Cone had been observed by the author, and also some other similar structures, the origin of which he hoped to discuss in a future paper.

Whenever displacement of any kind takes place in strata, the adjoining surfaces that thus move past each other do not usually again firmly unite; and hence various substances are often introduced by infiltration into the intervening spaces. In this way the surfaces of Stylolites and the enclosing rock not unfrequently become covered with oxides of iron, either in the form of deudrites, or of a uniform coating. Carbonate of lime, or of lime and magnesia, sulphate of lime, and of strontia when introduced, in this manner often crystallize in the grooves on the sides of the columns or sutures, thus apparently forming fibrous crystals; and consequently, these have, perhaps not unnaturally, been regarded as essential elements in the formation of Stylolites by those who had made but a limited study of the subject. Hence the various crystallization theories that have been proposed, each regarding the particular substance detected as the cause of the structure. The dark coating on columns and in sutures, which has been considered bitumen by several authorities, will generally be found, on examination, to be either a portion of the argillaceous layer, separated by the Stylolites when forming, or, as in the case of Slickensides, merely a portion of the rock, finely divided and compressed. The dark color may, of course, be heightened by the subsequent infiltration of organic substances, but the coating itself is in nearly all cases essentially inorganic.

The localities of Stylolites in this country are very numerous, and allusion has already been made to some of the more important. The most interesting one known to the author is in the Clinton limestone at Lockport, N. Y., where nearly all the perfect columns are crowned with fossils. The best exposure at this locality, now accessible, is at Cady's quarry, a few rods below the railroad bridge over the canal;

* A suite of specimens, from various localities in this country and in Europe, illustrating such a series, was exhibited by the author.

but the terrace of limestone on which this part of the city is built contains throughout its whole extent fine illustrations of this structure. Apparently the same beds are exposed in the railroad cutting on the Niagara River above Lewiston, nearly twenty miles distant, as layers having essentially the same position, and containing similar Stylolites, have been observed by the author there and at various points where the Clinton crops out along the "Mountain" ridge; and Dr. A. M. Leonard, of Lockport, has since discovered other intermediate localities, which render the connection more than probable, thus indicating a very large extent of surface, over which the same peculiar causes were in operation at the same time.

Besides the localities already referred to, many others of interest occur in the Silurian, Devonian, and Carboniferous, and more rarely in the Triassic. In New York and Canada the Niagara and Corniferous limestones often contain imperfect Stylolites in abundance, while in the West fine illustrations of the structure have been found in the subcarboniferous. Special localities may readily be ascertained by consulting the various State Geological Reports.

One of the most interesting localities of Stylolites in Europe is that already mentioned in the Muschelkalk at Rüdersdorf, near Berlin, where this structure is developed in great perfection. Nearly all the separate columns are capped with fossils, and a great variety may easily be obtained. During a visit to the locality in 1864, the author collected more than fifty characteristic columns, each having an organic covering, and among these ten species of fossils were represented. The Muschelkalk and Zechstein in other parts of North Germany also frequently contain Stylolites in abundance. In Würtemberg, columns with a black coating are common in the Muschelkalk near Friedrichshall, and at Rottweil Stylolites are occasionally found having on their summit a fossil crab.* Various localities of Stylolites have been observed in France, one of the most important of which is in the Jura near Dijon, where columns a foot in length were noticed by M. d'Aoust.† In Great Britain this structure appears to have attracted very little attention, and no localities of particular interest have been described. In the subcarboniferous limestones of Ireland the author had observed the more common varieties of Stylolites at several places, but the structure was nowhere well developed.

* Von Alberti. Uberblick über die Trias, p. 15.

† Bulletin Soc. Geol. de la France, Vol. III. p. 327.

II. PALÆONTOLOGY.

1. On some Fossil Reptiles and Fishes, from the Carboniferous Strata of Ohio, Kentucky, and Illinois. By J. S. Newberry, of New York, N. Y.

The specimens exhibited and described in this communication consisted of reptiles and fish from the cannel stratum underlying the main coal seam at Linton, Ohio, of fishes from the coal measures of Illinois, collected by the State Geologist, and of a group of fishes collected by Dr. Patterson from a stratum of bituminous shale, lying in the Waverley group, one hundred and twenty-five feet above its base, at Vanceburg, Kentucky. Of these, the first series included *Raniceps Lyellii*, Wyman, with several as yet undescribed reptiles, some of which apparently belong to Prof. Huxley's new genera, *Ophioderpeton* and *Urocordylus*. Associated with these were some twenty species of fossil fishes, most of which have been described by Dr. Newberry, but were now represented by new and more perfect specimens. Among these were eight species of *Eurylepis*, a genus created by Dr. Newberry to receive a group of small lepidoids, allied to *Palœoniscus*, but distinguished by the scales of the sides which are much higher than long. The scales on several of these species are very highly ornamented. The specimens exhibited were preserved in cannel coal, and covered with a film of sulphide of iron, by which they were brilliantly gilded. With these were two species of *Cœlacanthus*, some of the specimens of which showed that the fishes of this genus were furnished with a supplemental caudal fin, as in *Undina*. This Dr. Newberry stated was an interesting fact confirmatory of Prof. Huxley's view of the relations of *Undina*, *Macropoma*, and *Cœlacanthus*. The numerous and very complete specimens of *Cœlacanthus* exhibited supply much that was wanting to a perfect knowledge of the anatomy of this genus. The bones of the head are similar in form to those of *Macropoma*, are highly ornamented with tubercles above lines below. The jugular plates are double and long-elliptical as in *Undina* and *Macropoma*. The position and form of the fins are as in *Undina*, but the anterior dorsal is stronger. The fins are supported on palmated interspinous bones, similar, in a general way, to those of the other genera of the family. The paired fins are slightly lobed. The supple-

mental has been referred to. The scales are ornamented with curved and converging raised lines. In many specimens the earbones (otolites) are distinctly visible. Besides the fishes found at Linton already enumerated, there were scales and teeth of *Rhizodus*, two species, at least, one of which *(R. angustus)* has teeth of two forms, one large, flattened, and double-edged, the other smaller, more numerous, slender, sheathed, and conical, with a circular section throughout; two species of *Diplodus*, consisting of bony base and enamelled crown, — the latter distinctly and beautifully serrated, — so that there can scarcely be a question that they were teeth, and not, as claimed by Mr. Atthey, of Newcastle, England, dermal tubercles. In the Linton fauna is one species of *Palœoniscus (P. scutigerus. N.);* one of *Pygopterus*; one of *Megalichthys*, represented by scales; and numerous spines of placoid fishes of the genera *Compsacanthus* and *Pleuracanthus.*

The fish remains from Illinois consisted of a splendid specimen of *Edestus vorax* (Leidy), from the coal at Belleville, opposite St. Louis, and of several individuals of a new species of *Platysomus* from the concretions of iron ore at Mazon Creek. The *Edestus* was said by Dr. Newberry to have been described as a jaw, but the specimen exbibited was much more complete than any before found, and there could scarcely be a doubt that it was the spine of a Selachian. *Platysomus*, he said, though common in the coal measures of England, had not been before found in America.

The fishes from the Waverley were from a new locality, and from a horizon that had furnished very few fossils of any kind, and no fishes except a *Palœoniscus (P. Brainerdi)* found in Northern Ohio. The specimens collected at Vanceburg by Dr. Patterson consisted of teeth of *Cladodus* and *Orodus*, with spines of *Ctenacanthus*, with the tail of one of these Selachians distinctly preserved. This, Dr. Newberry said, was a great rarity, as the soft, and even the cartilaginous parts of plagiostomous fishes had usually disappeared, the teeth, spines, and dermal tubercles, the only bony parts, remaining. The only similar cases, of which he had any knowledge, was the discovery of the tail and fins of Chondrosteus in the Lias of Lyme Regis, England, and the preservation of *Thyalina* in the Solenhofen slate. The specimen shown was greatly older, being from the base of the carboniferous, and was the only figure that Nature had given us of the external form of these ancient sharks. This tail was very heterocercal, had the from of the

caudal fins of some living sharks, and indicated a fish of seven or eight feet in length. In the specimen exhibited the vertebral column had entirely disappeared, but the impressions of the spinous bones were distinctly visible, those of the lower lobe of the tail being ossified throughout. Dr. Newberry said that he hoped to gather data from this collection for uniting teeth and spines, which, though described under different names, were parts of one fish.

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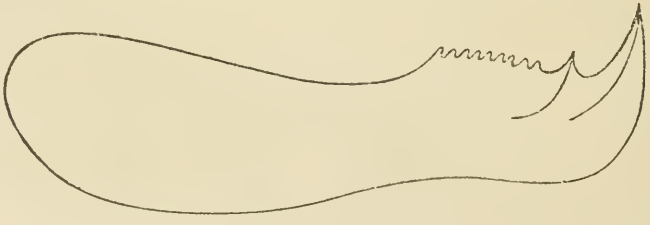
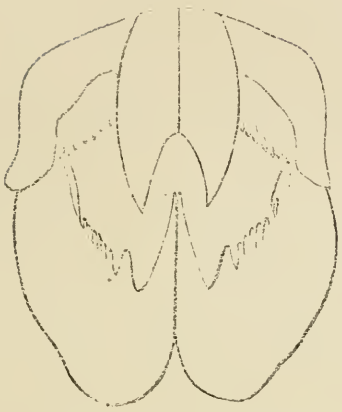
2. On some Remarkable Fossil Fishes, Discovered by Rev. H. Herzer, in the Black Shale (Devonian) at Delaware, Ohio. By J. S. Newberry, of New York, N. Y.

Dr. Newberry exhibited to the section different portions of the head of a gigantic fish, to which he had given the name of *Dinichthys Herzeri*, and which, he said, from its size and structure, deserved the same distinction among fishes that *Dinotherium* and *Dinornis* enjoy among mammals and birds. Most of the bones obtained as yet belonged to the head, which was over three feet long, by one and a half broad, and wonderfully strong and massive. All parts of the head had been procured, and many different individuals were represented in the collections made by Mr. Herzer. The cranium was composed of a number of plates firmly anchylosed together and strengthened near the occiput by internal ribs, or ridges, nearly as large as one's arm. The external surface was covered with a very fine vermicular ornamentation. The anatomical structure was more wonderful than the size, and was such as to separate this quite widely from any fishes known, living or fossil. The most marked peculiarity was in the structure of the jaws and teeth, both as regards the form and texture. The form of the jaws will be best understood by the following figures: —



Mandible one-eighth natural size.



Upper and lower jaws in position restored.

The head terminated anteriorly and above in two great incisors, representing the pre-maxillary, behind which, on either side, were the maxillaries, broad, flattened bones of very dense tissue, along the lower edge of which was set one row of small, robust teeth, which were neither implanted in sockets nor cemented to the jaw, but were formed by the consolidation and prolongation of the jaw tissue. The mandibles are over two feet long by six inches deep, laterally flattened and very massive, being without any medullary cavity. The anterior extremity was turned up in a huge triangular tooth, composed of dense, ivory-like tissue, which articulated with (passing between) the divergent incisors of the upper jaw. Back of this terminal tooth, on some specimens, was another triangular summit, behind which was a row of small teeth, corresponding to those of the maxillaries. Such was the power of this tremendous dental apparatus, that the bodies of our largest living fishes would be instantly pierced and crushed by it, if exposed to its action. Behind the head were large and thick plates, one of which corresponded to the "*os medium dorsi*" of *Heterostius* (Pander); being at least of equal size.

These interesting fossils were found in the calcareous concretions, which occur so abundantly near the base of the "Black Shale" (Hamilton) at Delaware, in Central Ohio, by Mr. Herzer, a clergyman, who, while performing his pastoral duties, and living on a very small salary, had been a most zealous and remarkably successful student of the local geology.

III. ZOÖLOGY.

1. On the Zoölogical Affinities of the Tabulate Corals. By A. E. Verrill, of New Haven, Conn.

The various kinds of coral-like structures are now well known to be produced by several very different classes of animals, and also, in some cases, by certain low plants. Thus we may have Molluscan corals *(Bryozoa)*; Corals of Halcyonoid Polyps *(Tubipora, Gorgoniæ,* red-coral); Corals of Madreporian Polyps *(Madrepora, Porites, Astræa, Mæandrina)*; Corals of Actinoid Polyps *(Antipathes,* etc.); Hydroid Corals *(Sertularia, Millepora)*; Protozoan Corals *(Polytrema* and various other stony sponges, *Eozoon* and other *Foraminifera)*; Vegetable Corals *(Nullipora Corallina,* etc.).

Although the nature of most of the living forms is now pretty well known, it is often very difficult to decide upon the affinities of various fossil forms, which have no living representatives. And since coral-like organisms are, next to shells, the most abundant and characteristic fossils in many formations, it becomes a matter of great interest to ascertain their true position in the Animal Kingdom. The periods when certain classes and orders of animals first appeared in geological time will, also, be materially changed by diverse interpretations of the affinities of fossil corals.

Among the most important doubtful groups, at the present time, are the Cyathophylloid Corals and the Tabulate Corals *(Zoantharia Rugosa* and *Zoantharia Tabulata,* Edwards and Haime). The former are referred by Milne Edwards and Haime, and most other writers, to the Madreporian Polyps, but as a distinct family, tribe, sub-order, or order, by different authors. Certain writers, however, have referred several of the genera to the mollusca, near *Hippurites.* But Prof. Agassiz refers the entire group, together with the *Tabulata,* to the Hydroids.*

The Tabulate Corals were introduced among the Madreporian Corals by Prof. Dana, in whose excellent work they form only a distinct group, but the genera were arranged according to characters other than the existence or absence of transverse plates. By Edwards and Haime

* Proceedings of the Boston Society of Natural History, Vol. VI. p. 373, 1859. Contributions to the Natural History of the United States, Vol. III. pp. 61–3 and IV. pp. 292–6 and 338.

they were united into one group, on account of this one structural character, the importance of which is very doubtful. Some of the Tabulate genera have also been referred elsewhere. Thus Rominger* has endeavored to prove that *Chætetes* and allied forms are *Bryozoa*, and Dana referred *Aulapora* and *Syringopora* to the Alcyonaria.

Prof. Agassiz observed the living animals of *Millepora* at the Florida reefs, and found that the larger cells are occupied by animals different from those that form the small ones scattered between them, and that both kinds correspond with the polymorphous individuals that form the compound colonies of many kinds of Hydroids. In the animals of *Millepora*, as figured and described by Prof. Agassiz, the mouth is at the prominent extremity of the long, slender, or clavate body, and the short, capitate tentacles do not form a circular wreath around a distinct oral disk, but are clustered around the upper part of the body in an irregular manner. The tentacles, like the whole body, have the Hydroid characters well marked.†

Finding the tabulated *Millepora* a well-characterized Hydroid, Prof. Agassiz very naturally referred all other *Tabulata* to the same order, although among them there are several distinct types of structure, very different from *Millepora*. On account of the existence of transverse plates or septa in many *Rugosa*, he supposed that this group would also prove to be Hydroids. As there are no living representatives of these, it will be very difficult to determine their true nature with certainty, but there are apparently many good reasons for retaining them among the true *Polypi*. Many of them, also, do not present transverse septa, while the radiating septa are often highly developed, indicating that the body of the animal was divided up into radiating chambers, a feature not found among Hydroids, but most characteristic of the true Polyps.

Among the tabulated corals, we find two well-marked groups. The first includes *Millepora* and *Heliopora* among living corals, *Heliolites*, and many other fossil genera. In these there are nearly circular, tubular cells, separated by a porous cœnenchyma, in which there are smaller

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* Proceedings of the Philadelphia Academy of Natural Sciences. 1866, p. 113.

† Prof. C. Fred. Hartt informs me that while collecting specimens of *Millepora* (*M. alcicornis L., M. nitida V.* etc.) at St. Thomas and on the coast of Brazil, they stung his hands severely in parts where the skin is tender, unless handled with great care. This, also, is a character of the Hydroids rather than of the true Polyps. A large Hydroid was observed by Mr. Bradley at Panama to have the same power.

cells, which sometimes form circular clusters around the larger ones. The two forms of the cells indicate the dimorphous character of the animals forming them, which is a common if not characteristic feature of many families of Hydroids.* The cells themselves are divided transversely by more or less numerous plates, but the radiating septa are either entirely absent or represented only by slightly raised lines upon the walls of the cells or the upper surface of the transverse septa.

The second group, including Pocillipora and Seriatipora, among living corals, and Favosites, Columnaria, etc., among fossil ones, contains genera that have the cells all similar, and usually united directly together by the distinct walls, or a compact cœnenchyma. In these the transverse plates are usually quite as regular and complete as in the first group, or even more so, but the radiating septa are also frequently very well developed, forming cycles of six, twelve, twenty-four, or other multiplies of six, precisely as in the Madreporians, and in some cases these extend inward from the wall, so as to join a central columella. In some species of Pocillipora † there are twelve radiating plates, as well developed as those of many true Madrepores.

Hoping to gain some positive evidence upon this question, Mr. F. H. Bradley, while collecting specimens at Panama for the Museum of Yale College, was requested to examine the living animals of *Pocillipora capitata* V., which occurs in that region quite commonly. This he was able to do without much difficulty, since the polyps of *Pocillipora* are tolerably large and expand readily in confinement, differing greatly in both these respects from those of *Millepora*. Although provided only with a good pocket lens, his observations and drawings are of importance with reference to the question under discussion. A careful microscopic examination is, however, still very desirable. According to his drawings and descriptions, this *Pocillipora* has exsert polyps, with twelve equal, round, moderately long, tapering tentacles, which surround the edge of the oral disk in a single circle, six being ordinarily held upright, while the alternate six bend outward. Twelve radiating lines, considered to be the edges of the internal radiating lamellæ, showing through the translucent disk, pass from between the bases of the tentacles to the stomach. Thus these animals have all

* Dimorphism among true Polyps is known only in the *Penatulacea*, and in the genus *Sarcophyton*, among the *Alcyonaria*, unless the terminal polyps of *Madrepora* be considered a dimorphous form.

† *Pocillipora stellata* Verrill, from Zanzibar, is a good example.

the external characters of those of *Porites* and *Madrepora*. Indeed, Mr. Bradley states that when comparing the expanded polyps of the *Pocillipora* and a species of *Porites*, living with it, and placed side by side, he could see no difference except in the color and posture of the tentacles, those of the *Porites* being held all in the same position. From these observations it seems necessary to conclude that *Pocillipora*, and other *Tabulate Corals* belonging with it, are true Madreporian Polyps, allied to the *Poritidæ* in some characters, and to *Stylophoridæ* in others,* but forming two or more distinct families.

If these conclusions be well founded, the *Tabulata* form an artificial and unnatural group, which should be dismembered and the various genera distributed between the Hydroids and Madreporian corals, in accordance with other and more important characters.

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2. Considerations drawn from the Study of the Orthoptera of North America. By Samuel H. Scudder, of Cambridge, Mass.

The Orthoptera of North America have received, as yet, but little attention. Those of New England alone have been carefully enumerated. Any comparison, therefore, of the Orthoptera of Europe and America must be based, so far as this continent is concerned, on our knowledge of the New England fauna. This limited region has a numerical preponderance of species over any European district of equal extent with which it can fairly be compared. Situated in the latitude of Southern Europe, the climate and physical features of New England bear a stronger resemblance to the Scandinavian peninsula than to any other part of Europe. Yet New England possesses seventy-nine species of Orthoptera, and Northern Europe has scarcely more than half that number, viz., forty-three. In point of numbers, the Orthoptera of New England stand midway between those of Northern and Middle Europe, the latter having one hundred and twenty-six species.

A separate comparison of the families brings to light some very interesting features.

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* In the Voyage de l'Astrolabe, Quoy and Gaimard have figured two species of "Pocillipora," both having twelve equal, tapering tentacles. One of these is a *Stylophora*, according to Edwards and Haime, but the other seems to be a true *Pocillipora*.

One-eighth of the species of Forficulina which occur in Europe are found in the northern part, one-half in the middle, and five-eighths in Southern Europe. North America does not seem to be rich in Forficularians. New England possesses but two species, or one less than is found in Northern Europe.

One-fifth of the species of European Blattina occur in the northern part of the continent, one half in the middle, and seven-eighths in Southern Europe, showing a great preponderance of species towards the south. New England has seven species, and stands midway between Northern Europe (five) and Middle Europe (nine).

No species of Mantis occurs in New England, although one species is found in Maryland, and another is described (erroneously?) from New York. In Europe, one species alone extends as far north as Middle Europe. A single species of Phasmida is found in the southern half of New England, but no species occurs either in Northern or Middle Europe; two are described from Southern Europe.

Of Gryllodea, a single or at most two species occur in Northern Europe. Ten species, or two-fifths of those found on the whole continent, occur in Middle Europe, and seven-eighths of the whole number in Southern Europe. In New England there are eleven species.

Of Locustariæ, Northern Europe possesses fourteen species, or two-elevenths of the whole continental fauna; Middle Europe has thirty-nine, or one-half of the whole, while Southern Europe has forty-nine, or five-eighths. In this group we begin to have a more equable proportion, approaching to a balance of species between the North and South. Here, also, New England, which has only sixteen species, is more closely allied to Northern Europe. New England, however, cannot always be taken as a representative of the whole continent; for America is extremely well supplied with species of this family, and peculiarly so in the case of certain genera.

Twenty species of Acridiodea, or more than one-fourth of the whole continental fauna, are indigenous to Northern Europe. Middle Europe has fifty-five species, or five-eighths of the whole number, while Southern Europe possesses only fifty-one. This shows that the family affects the more temperate regions. It is the only family of Orthoptera in which there is a preponderance of species towards the North. New England, however, contrary to what we should expect from our comparison of the Locustariæ, is extremely rich in forms of this family, forty-two species being found within its limits. The other portions of America are almost equally rich.

The following genera of Orthoptera occur in New England, and are unrepresented in Northern and Middle Europe: Diapheromera, Panchlora, Platamodes, Ceuthophilus, Cyrtophyllus, Microcentrum, Tragocephala, and Tettigidea. Very many more, including many genera yet undescribed, might be added from other parts of North America. On the other hand, Onconotus, Orphania, Odontura, Saga, Locusta, and Decticus, which occur in Northern and Middle Europe, will be vainly sought for in New England. The genera Forficula and Stenobothrus are much more richly developed in Northern and Middle Europe than in New England.

Going beyond the limits of New England, we shall find in Europe but one or two representatives of the sub-family which includes Hadenœcus, or the genus of Orthoptera, found in the caverns of Austria and Kentucky, while America contains many genera, and very many species, especially in the genus Ceuthophilus. Conocephalus is also richly developed in America. I am acquainted with nearly twenty species, while only one species is found in Europe. Finally, oedipoda and the family of minute Tettigideans are much more abundant in America, and even in New England alone, than in the whole continent of Europe.

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3. The Embryology of Libellula (Diplax) with Notes on the Morphology of Insects and the classification of the Neuroptera. By A. S. Packard, Jr., of Salem, Mass.

This paper embraces a description of the egg and the evolution of the embryo, of which seven successive stages are described.

These stages are represented by the following steps: 1°, The formation of the anterior part of the head, the ventral wall of the thorax, and the formation of the mouth-parts and thoracic appendages.

2°, The appearance of the rudiments of the eyes. The appearance of the abdomen. This stage is compared with the embryo of the spider, as worked out by Claparède, and of the crawfish, as studied by H. Rathke.

3°, The differentiation of the head into the eye-bearing piece, the epicranium and clypeus, and the approximation of the fourth pair of appendages destined to form the labium. The appearance of the rudiments of the anal stylets. The closure of the dorsal wall of the

body over the yolk mass. The three divisions of the body into head, thorax, and abdomen have now become distinct.

4°, The appearance of articulations in the appendages. The labium rests flat upon the under side of the body, the articulations of the thorax and abdomen appear, and there is a greater equality in the size of the three regions of the body than before. Appearance of the nervous ventral cord. Formation of the tracheæ and alimentary canal.

5°, Lepisma-like stage. 6°, Thickening of the abdomen. The labium is raised from the breast towards the mouth.

7°, Description of the newly-hatched larva, and its transformations. General conclusions.

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4. The Insect Fauna of the Summit of Mount Washington, as compared with that of Labrador. By A. S. Packard, Jr., of Salem, Mass.

The following notes are thrown together rather to furnish a summary, from data only approximately correct, of our present knowledge of the distribution of Alpine and Arctic Lepidoptera, than to give anything like a complete account.

The summit of Mount Washington, or that portion lying above the limit of trees, agrees in its climate and other physical features very closely with those of the coast of Northern Labrador, as observed at Hopedale, in latitude 55° 35′.

The seasons correspond very exactly, as the snow melts in the early summer, and ice is formed early in the autumn at about the same dates.

As is well known, the Alpine flora of the White Mountains is identical with that of the arctic regions, which extends far southward along the Atlantic shore of Labrador. Not only is the flora identical so that no species of plant is known to be restricted exclusively to our Alpine summits, but the times of leafing, of flowering, and fruiting of plants is much the same. Such was observed in the *Rubus chamæmorus* and *Arenaria Greenlandica*, for example.

It is also the same apparently with the fauna. The *Chionobas semidea* flies late in July and early in August, in greatest abundance, at the same time that its representative species swarm over the bare, rocky hill-tops of the Labrador coast. Their appearance heralds the close of summer, both on the extreme summit of Mount Washington and the exposed hills of Labrador.

Most is known of the Lepidopterous fauna of Alpine and arctic regions, both in America and Europe, and our data will be drawn from this group of insects. In Europe, Thunberg, Zetterstedt, Duponchel, Boisduval, Staudinger, and Wocke, have studied the circumpolar lepidopterous fauna; Möschler and Christoph, Clemens and Scudder and the writer, have described the insects of Labrador, and Messrs. Scudder, Shurtleff, and Sanborn have explored the insect fauna of Mount Washington, and other Alpine summits.

According to Dr. Staudinger, out of sixteen butterflies found in Finmark, two only (*Erebia Manto* and *Argynnis Thore*) occur in the Alps and also in Siberia. But two or three butterflies, among them *Chionobas Aello*, so far as we have been able to learn, are peculiar to the Alps. Of 122 species of lepidoptera inhabiting Labrador, 70 are found only in Labrador and Arctic America, while 43 are circumpolar, namely, occur on both sides of the Arctic Ocean, being found in Finmark and the mountains of Norway; six species inhabit the summit of Mount Washington, and five of the whole number also inhabit the Swiss Alps. Two of the European Alpine species are found on Mount Washington, New Hampshire. The following table gives a summary of the distribution of the species of the different families.

DISTRIBUTION OF LABRADOR LEPIDOPTERA.

NAMES.	Circumpolar.	Labrador and Arctic America exclusively.	Alps.	Mt. Washington.
Butterflies . .	5	8		
Bombycidæ . .	1	2	1	1
Noctuidæ . .	19	13	4	2
Phalænidæ . .	10	16		2
Pyralidæ . . .	3	10		
Tortricidæ . .	3	14		1
Tineidæ . . .	2	7		
Total . .	43	70	5	6

Certain genera among insects, as among Mollusca, are almost exclusively arctic. Such are *Chionobas* and *Anarta*, which are paralleled by the two marine genera *Astarte* and *Buccinum*.

Two species *Lycaena Aquilo* (*Polyommatus Franklinii*) and *Cidaria polata*, abounding in Labrador and the polar regions, have not yet been found on Mount Washington. This is paralleled by the occurrence

of certain mollusca, e. g. *Leda truncata*, in the high arctic seas, which have become extinct in the seas southward, where they are now found fossil; so that the distribution of the arctic insect fauna seems to be paralleled by that of arctic marine invertebrates. As in the temperate seas certain abysses and banks swept by the arctic currents are peopled by outliers of an arctic marine fauna, so the Alpine elevations or atmospherical abysses, rising out of a temperate into an arctic climate, seem peopled by outliers of an arctic land fauna. These outliers are relics of an arctic fauna, that during the early part of the Quaternary period, i. e. the Glacial Epoch, peopled the surface of the temperate zone.

We cannot suppose a special creation of organized beings for the Alpine summits. *Chionobas semidea* and *Argynnis montinus*, thus far only known to inhabit the summit of Mount Washington, may still be found northward; or, if not, probably became extinct north, finally localizing themselves on the single peak where they now occur.

On the other hand the occurrence of *Chionobas Chryxus* Doubld. on Pike's Peak, and *Chionobas Nevadensis* Boisd. found in Nevada, is in favor of those species being autochthonous, though they may yet be found northwards towards the arctic circle.

The Zygænidæ are represented in arctic Europe and the Alpine summits by *Zygæna exulans;* but this is not a circumpolar or arctic species. No member of this family, or of the Sphingidæ or Ægeriadæ is circumpolar or found in Arctic America.

Of the *Bombycidæ* but one species, *Arctia Quenselii* is circumpolar, being found in Finmark and Labrador, and also on the Alps and Mount Washington. An allied form, if it be not a mere variety of this variable species, *A. cervini* Guènee, is found on the Alps.

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* Since publishing the View of the Lepidopterous Fauna of Labrador (Proceedings Boston Soc. Nat. Hist. Jan., 1867), I have received a valuable collection of arctic moths from Dr. Staudinger, which have enabled me to compare the Labrador species more satisfactorily with European types.

Anarta nigro-lunata Pack. This is identical with *A. melanopa*. Two males, one from Labrador and the other from the summit of Mount Washington, New Hampshire, scarcely differ; the latter specimen is a little larger, and the hind wings are a little more dusky at base, the blackish portion partly including the discal dot, while the black border is a little broader than in the Labrador specimen. A female from the Swiss Alps is still more dusky on the hind wings.

Anarta leucocycla Staud. Was found on Mount Washington in July, and is like specimens from Labrador and Lapland.

Anarta bicycla Pack. is identical with *A. melaleuca* (Thunberg) from Lapland.

Another form, *Orgyia? Rossii*, is found in Arctic America and Labrador; *Platarctia borealis* occurs in Labrador, while a representative species and very closely allied, *P. parthenos*, is found at Lake Superior and the White Mountains.

There are no autochthonous species in Northern or Alpine Europe that seem to offset these two species. Platarctia is a truly American genus, and the affinities of the genus to which *Laria* (*Orgyia?*) *Rossii* belongs are as yet conjectural.

Of the extensive family Noctuidæ, there are thirty-one species found in Labrador. Of these, thirteen are, so far as known, only found in Labrador; about nineteen are circumpolar, or found on both sides of the Northern Atlantic; thirteen have thus far only been detected in Finmark, while four occur on the Alps. Two species have been detected on Mount Washington.

Of the genus *Anarta*, twelve inhabit Labrador (this including A. luteola Grote, discovered at Quebec), twelve live in Finmark; two species, *A. melanopa* and *A. funesta*, inhabit the Alps, and two also the summit of Mount Washington. The European Alpine species are *Anarta melanopa* and *A. funesta*, while *A. melanopa* and *A. leucocycla* live on Mount Washington. *A. melanopa* is circumpolar and Alpine on both hemispheres, while *A. funesta* and *A. leucocycla* are only circumpolar.*

No species is known to us to be exclusively Alpine.

Of the Phalænidæ less is positively known, as the Labrador species have not been so carefully compared with those of Arctic Europe, and several of those described from Labrador may prove to be synonymes of European forms.

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* *Cidaria truncata* Hufn. var. from Iceland. A specimen from Carribou Island, Straits of Belle Isle, belongs to this form, in which the middle of the wing is grayish, not being so dark as the more typical specimens.

Cidaria aurata Packard. From the White Mountains and Labrador; is distinct from but allied closely to *C. cæsiata* from Lapland.

C. abrasaria H.-S. A specimen from Carribou Island agrees well with a specimen from Iceland sent by Dr. Staudinger.

Cidaria nigro-fasciata Packard, from Labrador, is very closely allied to *C. abrasaria* H.-S. found in Finmark and Lapland, and may prove to be a variety of it.

Melanippe hastata (Linn). Specimens from Lapland are not distinguishable from M. gothicata Guèn, taken in Labrador.

Staudinger states that of thirty species of this family found in Finmark (which is almost exactly the geographical equivalent of Labrador), three are found in the Alps, and five are polar.

On the other hand, of twenty-six species thus far found in Labrador, ten are circumpolar, and two occur on Mount Washington, leaving sixteen indigenous to Labrador.

Of the distribution of the remaining lepidopterous families what little is known is exhibited in the preceding table.

NOTE TO THE PAPER OF J. P. PERRY.

(TO BE INSERTED IN PAGE 134.)

The following brief list of primordial fossils found in Vermont will make the discordance, to which I have alluded, evident. Omitting the Lower Taconic, and reading from below upward, we have:

II.	Potsdam Sandstone.	Conocephalites Vulcanus (B.). Conocephalites Adamsi (B.). Brachiopods, several undescribed species. Lingula, probably two species. Crinoids. Scolithus linearis (H.). Fucoids, described and undescribed.
I.	Georgia Slate.	Articulates, probably two undescribed species. Conocephalites Teucer (B.). Olenellus Vermontana (H.). Olenellus Thompsoni (H.). Camerella antiquata (B.). Orthisina festinata (B.). Orthis, undescribed. Obolella cingulata (B.). Palæophycus congregatus (B.). Palæophycus incipiens (B.). Chondrites, one or two undescribed species.
	Swanton Slate.	Articulates, one or two undescribed species. Atops trilineatus (Em.). Graptolites, several species.

TITLES

OF

COMMUNICATIONS.*

A. MATHEMATICS, PHYSICS, AND CHEMISTRY.

1. New Determination of the Distance of the Sun. By Simon Newcomb.
2. On the Velocity of Transmission of Signals by the Electro-Magnetic Telegraph. By B. A. Gould.
3. Cosmogony. By L. Bradley.
4. On the Effect of Sunshine on Fires. By E. N. Horsford.
5. On the Theories of Boussingault and Thenard of the Difference between Stale and Fresh Bread. By E. N. Horsford.
6. Note on the Duke of Argyll's Theory of the Mechanism of the Flight of Birds, with Illustrations, derived from the Trachilidae. By L. E. Chittenden.
7. Remarks on the Law of Winds, with some Account of Progress in the Investigation of the Same. By James H. Coffin.
8. The Geodetic Triangulation of the Coast of New England. By A. D. Bache, late Superintendent of the U. S. Coast Survey. By J. E. Hilgard.

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* The following papers were also read: of some, no copy has been received for publication; of others, it was voted that the title only should be printed. No notice, *even by title*, is taken of articles not approved.

9. On Isothermals and Abisothermals. By Joseph Henry.
10. Suggestions on the Scientific and Practical Relations of Wood-spirit. By James Hyatt.
11. On the Use of Months for Dates. By J. F. Holton.
12. On the Metallic Thermometer. By J. F. Holton.
13. On Euler's Universal Formula for the Summation of Series. By David Trowbridge.
14. On Elliptic Integrals by Series. By David Trowbridge.
15. Molecular Motions. By H. F. Walling.
16. On the Conversion of Iron into Steel by Means of Carburetted Hydrogen. By James Hyatt.
17. On a Knowledge of the Satellites of Jupiter before the Time of Galileo. By James Hyatt.

B. NATURAL HISTORY.

18. On Certain Effects produced upon Fossils by Weathering. By O. C. Marsh.
19. On some new Fossil Sponges from the Lower Silurian. By O. C. Marsh.
20. On the Distribution of the Precious Metals in the United States. By Charles Whittlesey.
21. On the Structure of Ice in its Relations to the Sudden Disappearance of Ice on Lake Champlain. By E. N. Horsford.
22. On the Geographical Distribution of Radiates on the West Coast of America. By A. E. Verrill.
23. On some Peculiar Parasitical Relations between Crustacea and Radiates. By A. E. Verrill.

24. On the Cretaceous and Tertiary Floras of North America. By J. S. Newberry.

25. On the Geological Relations of the Mastodon and Fossil Elephant. By James Hall.

26. On the Geographical Distribution of the Sediments and of the Fossils in the Hamilton Portage and Chemang Groups of New York. By James Hall.

27. Notes on the Distribution of Limnea Megasoma and Cognate Genera. By L. E. Chittenden.

28. On the Occurrence of Fossil Sponges in the Successive Groups of the Palæozoic Series. By James Hall.

29. On the Value of the Hudson River Group in Geological Nomenclature. By James Hall.

30. Indian Architecture. By Louis H. Morgan.

31. The American Beaver. By Louis H. Morgan.

32. Explanation of a Geological Map of Maine. By C. H. Hitchcock.

33. Remarks on the Coal Measures of Illinois. By A. H. Worthen.

34. The Phenogamous Plants of South Eastern New York. By James Hyatt.

35. Remarks on the Ichthyological Fauna of Lake Champlain. By F. W. Putnam.

EXECUTIVE PROCEEDINGS

OF

THE BURLINGTON MEETING, 1867.

HISTORY OF THE MEETING.

The Sixteenth Meeting of the American Association for the Advancement of Science was held at Burlington, Vermont, commencing on Wednesday, August 21, and continuing to Monday Evening, August 26.

Seventy-three names are registered in the book by members who attended this meeting. Forty-seven new members were chosen, of whom, however, only twelve have as yet signified their acceptance by paying the annual assessment, and, when practicable, signing the constitution. Seventy-five papers were presented, most of which were read, and some of them discussed at great length.

The sessions of the Association were held in the City Hall and the adjoining Court House. At about 10 o'clock A. M. on Wednesday the members were called to order by the Permanent Secretary, Joseph Lovering, in the absence of Ex-President Barnard, and Prof. J. S. Newberry was introduced as the President of the Association for the year. At the request of the Standing Committee, prayer was offered by Prof. M. H. Buckham of the University of Vermont. After which Hon. Torrey E. Wales, Mayor of the City of Burlington, welcomed the members of the Association, in behalf of the citizens, in the following words:—

MR. PRESIDENT AND GENTLEMEN OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE: —

It is my duty and pleasure on this occasion to welcome you to Burlington. I feel some degree of embarrassment in addressing you these few words of welcome, because I know so little of the history of your Association I have learned, however, sufficient in regard to it to convince me that it merits the sympathy and support of all good men.

Its great aim seems to be to bring together, once in every year, the votaries of science in all its various departments, throughout the country, that they may interchange thoughts and opinions, investigate and discuss questions of scientific interest, and by their union of effort promote the advancement of science.

And this we understand to be the object of the present meeting, and in behalf of the people of Burlington I give you a very cordial welcome to our city. But after the magnificent reception and entertainment which you received from the generous citizens of Buffalo last year, what can the people of Burlington ever hope to do in comparison? Our city is not yet three years old, and has less than ten thousand inhabitants, and possesses few of the attractive features of large cities.

It is now in a condition very similar to that of the young man who commences life with no other capital than his *good name*, but with an inflexible determination to improve his condition.

This is our situation, and the members of this Association, having assembled here, must now accept it. It was rather a surprise to us that you selected this place for your present meeting, but we do not despair of the result, for we know that no place, however small, is devoid of interest to men of scientific culture, and that such men will make their meeting successful whether they receive the aid and sympathy of other men or not.

But the people of Burlington will do their whole duty upon this occasion. They will spare no pains to place at your command whatever they have that will contribute to your convenience or pleasure while you remain. I cannot promise you the sumptuous entertainment that you would doubtless receive in the large cities, but I can assure you that the hospitality of our citizens towards the members of this Association will be limited only by the means at their command. And I can also assure you that our people are deeply interested in the suc-

cess of this meeting, and are heartily in sympathy with its object; and though most of them are engaged in the ordinary pursuits of life, they, nevertheless, appreciate the value of education, and contribute freely of their substance to its support, and are not unmindful of the presence of your learned body in our city at this time. But among my fellow-citizens there are those who can better appreciate the interests of science, because they, like yourselves, pursue knowledge in the love of it. This occasion will be to them one of special interest, and they will welcome you as friends and co-laborers in the cause of truth and humanity.

Men of science deserve our love and sympathy; for they labor and toil, not for wealth or station, but for the cause of truth alone, and are deserving of the gratitude of mankind, for the unnumbered blessings which they have conferred upon the race. Other men may contend for political place and preferment, but the true philosopher seeks another and purer atmosphere. His is a life of constant study and of intense thought. He finds his pleasure and delight in the contemplation of those sublime truths which God has impressed on all his works. The star above, the blade of grass, the grain of sand upon the seashore, all alike furnish him subjects for earnest thought and meditation, which a life-time of devoted study cannot exhaust.

And now, may this meeting, and all future meetings of this Association, be crowned with perfect success; and may the cause of science ever prosper in your hands. The people of Burlington are deeply indebted to you for the honor you have conferred upon them in this present meeting of your venerable body, and for the happy influences which such a meeting will exert upon this community, and they will ever remember the Sixteenth Annual Meeting of this Association with just pride and satisfaction. And may the members of this Association have equal cause to rejoice over the success of this meeting; and at the close of your labors here, may you carry with you to your homes some pleasant memories of this occasion, and of Burlington.

This address of Mayor Wales was acknowledged by President Newberry, in behalf of the Members of the Association, substantially as follows: —

I should not properly express the feelings of the members of the Association did I not say that they congratulated themselves upon the place selected for this meeting. They could not have selected a more

agreeable place, both from its beautiful surroundings and historic associations. I have no fears as to their reception; an excess of hospitality which directs the attention of the members from the regular business of the meeting is out of place. I thank the citizens for their interest in the Association. It was determined to be useful. The functions of the Association are for the encouragement of learning which may be diffused among the people. In such a mission an institution of this kind should be sustained. The advance in scientific knowledge made in this country has been rapid, and I am confident our future will develop other more useful and more startling facts. Of all associations for this purpose, the American is the best. It is in fact the foundation of all.

Modesty prevents many men from coming forward, who could contribute much to the cause of science. It is the object of this organization to draw such out. I hope the Association will flourish and be of greater usefulness and importance to the country.

The Association then proceeded to the election, by ballot, of six additional members of the Standing Committee, according to the requirement of Rule 6 of the Constitution. The names of those chosen are printed elsewhere with the names of the other members of that committee.

The Association voted to hold its next meeting at Chicago, Illinois, beginning on Wednesday, August 5, 1868. The officers elected for the next meeting are: —

Dr. B. A. Gould, of Cambridge, *President;* Col. Charles Whittlesey, of Cleveland, *Vice-President;* Prof. A. P. Rockwell, of New Haven, *General Secretary;* Dr. A. L. Elwyn, of Philadelphia, *Treasurer*. Prof. Joseph Lovering was elected *Permanent Secretary* for another term of two years commencing with the Chicago Meeting.

Dr. B. A. Gould was appointed to deliver a eulogy on the late Prof. A. D. Bache at the next meeting of the Association.

On Thursday evening a general meeting was held in the Court House at which Prof. Joseph Lovering exhibited his experiments on the "Optical Method of Studying Sound;" and, on Friday evening, a general meeting was held in the Lecture Room of the College Street Congregational Church, when the President, J. S. Newberry, delivered

an address on "Modern Scientific Investigation, its Methods and Tendencies."

Many of the members in attendance upon this meeting accepted the private hospitality, generously offered by families in the city of Burlington.

On Saturday, August 24, after a short session of the Sections in the morning, which was continued in the evening, the members of the Association and their ladies, accompanied by many ladies and gentlemen of Burlington, by invitation of the *Champlain Transportation Company*, embarked on board the beautiful Steamer *Adirondack* and visited Port Kent and the Ausable Gorge, near Keeseville. On their return they were bountifully entertained on board the steamer, while moving up and down the Lake and enjoying interesting views of *Willsboro' Bay*, the Islands of *Les Quartre Verts*, and *Juniper Island*. On Monday evening, August 26, the members of the Association had an evening reception at the house of Dr. William C. Hickok. On Tuesday morning, after the adjournment of the Association, about twenty members availed themselves of an invitation, which the Association had received and accepted from the Mount Mansfield Hotel Association, to visit Mount Mansfield. They were met at Stowe by Mr. W. H. H. Bingham and, under his escort, were conducted to the summit of the mountain, where they passed the night, enjoying the hospitality of the Mountain House as well as that of the Mansfield House at Stowe.

RESOLUTIONS ADOPTED.

The following Resolutions offered by Prof. Alexis Caswell were, on his motion, referred to the Committee on Weights and Measures of the Association: —

Resolved, That the Association reaffirms its earnest and cordial sympathy with legislation tending to the adoption, as soon as may be practicable, of the metrical system of weights and measures.

Resolved, That, whereas the gold dollar of the United States bears practically a simpler relation to the metrical system of weights than the gold monetary unit of any other country — and, whereas the present dollar is the unit more extensively used among commercial nations than any other: — therefore, in the opinion of this Association, it is inexpedient to disturb or change, without the most cautious and careful consideration, either the weight or fineness of the existing monetary unit of the United States, viz. the gold dollar.

Resolved, That copies of these Resolutions be forwarded by the Permanent Secretary of this Association to the Secretary of the Treasury, the Chairman of the Committee of Finance of the U. S. Senate, and to the Chairman of the Committee of Ways and Means of the U. S. House of Representatives.

The following Report of the Committee on Weights and Measures was read: —

The undersigned, in behalf of the Committee on Weights and Measures, to whom the Resolutions have been referred by the Association, reports a cordial approval of the Resolutions. But, owing to the absence of the majority of the Committee (of whose approval he also feels convinced), he begs leave to ask the concurrence of the Standing Committee, before reporting them to the Association with the recommendation that they be adopted.

(Signed) B. A. Gould.

The Standing Committee having expressed their concurrence in the Resolutions offered by Prof. Caswell, they were unanimously adopted by the Association.

Resolved, That Dr. John Torrey be appointed to fill the vacancy in the Committee on Weights and Measures made by the death of Prof. A. D. Bache.

On the motion of Dr. Henry Wheatland the following Preamble and Resolution were adopted: —

Whereas the cause of science and education has been largely promoted by the recent munificent endowments of George Peabody, Esq., who has appropiated for these purposes an amount exceeding the sum of four millions of dollars: —

Resolved, That the American Association for the Advancement of Science cordially tender to Mr. Peabody their sincere thanks for his noble contributions to science, and trust that his highest expectations, in the bestowal of these gifts, will be fully realized, and that these efforts in behalf of human culture and progress will conduce to the increased prosperity and happiness of the American people.

Voted, That this Resolution be transmitted to Mr. Peabody by the President of the Association.

Resolved, That Dr. B. A. Gould be invited to deliver a eulogy on the late Alexander D. Bache, at the next meeting of the Association.

Resolved, That Prof. Joseph Lovering be invited to exhibit at a quarter before eight o'clock on Thursday Evening, August 22, 1867, in the Court House, the apparatus shown by him in connection with his paper on the "Optical Method of Studying Sound."

Resolved, That the Association accept with thanks the invitation presented by the Directors of the Champlain Transportation Company to make an excursion in the Steamer Adirondack on Saturday, August 24, to view the Gorge of the Ausable River.

Resolved, To accept the invitation of W. H. H. Bingham, of Stowe, to visit Mount Mansfield and the Mansfield House at Stowe, as his guests.

In SECTION B, the following resolution, offered by Prof. O. C. Marsh in behalf of the Sectional Committee, was adopted: —

Resolved, That a commission of nine members be appointed by the chairman to examine the Linnean Rules of Zoölogical nomenclature by the light of the suggestions and examples of recent writers, and to prepare a code of laws and recommendations, in conformity with just modern usage, and to be submitted to the Association for their approval at the next annual meeting, this commission to have authority to fill vacancies and to enlarge their number to twelve, if deemed desirable.

Committee appointed by SECTION B. to revise Zoölogical Nomenclature.

J. D. DANA,
JEFFRIES WYMAN,
S. F. BAIRD,
JOSEPH LEIDY,
J. S. NEWBERRY,
J. W. DAWSON,
WILLIAM STIMPSON,
S. H. SCUDDER,
F. W. PUTNAM.

VOTES OF THANKS.

Resolved, That to the Mayor and Common Council of Burlington, for their tender of rooms in the City Hall and Court House for the use of this meeting; to the Trustees of the Congregational Church on College Street for similar kindness; and to the President and Trustees of the College for their courtesy and cordiality, the thanks of this Association are due, and that we accept these favors from City and Church and School in the frank, free spirit in which they were offered, as a symbol of that fraternal union which exists between Virtue, Education, Good Government, and Science.

Resolved, That our thanks are due, and are hereby heartily tendered to the Local Committee and to the Local Secretary, for the admirable arrangements they have made, which have facilitated the business of the Association during the present meetings.

Resolved, That the thanks of the American Scientific Association be presented to the Champlain Transportation Company for their courtesy and liberality in providing for the Association the delightful excursion to the grand scenery of the Ausable, and for the bountiful collation and charming sail among the islands of the Lake on the steamer *Adirondack*.

Resolved, That the thanks of the Association be presented to the Directors of the Vermont Central Railroad, the Rutland and Burlington Railroad, the Vermont Valley Railroad, the Rennselaer and Saratoga Railroad, and the Lake Champlain Transportation Company, for their liberality in furnishing free return tickets to those members of the Association who came to the meeting over these roads or by the Lake.

Resolved, That the thanks of the Association be presented to the citizens of Burlington for the generous and elegant hospitality which they have extended to its members during the session.

REPORT OF THE PERMANENT SECRETARY.

This report includes the business which relates to the interval between the commencement of the Buffalo meeting (August 15, 1866) and that of the Burlington meeting (August 21, 1867).

The Association now consists of five hundred and thirty-nine members. Eighty new members were added at the Buffalo meeting, and one hundred and sixty-six old members were struck from the list, on account of three years' delinquencies in the payment of assessments, their aggregate indebtedness to the Association amounting to fourteen hundred and ninety-four dollars ($1,494).

The financial condition of the Association is as follows: —

Between August 15, 1866 (the first day of the Buffalo meeting), and August 21, 1867 (the first day of the Burlington meeting), the income of the Association has amounted to one thousand and fifty-six dollars and seventy-seven cents ($1,056.77) of which thirty-five dollars and fifty cents ($35.50) came from the sale of copies of the printed Proceedings, and the balance from assessments.

The expenses of the Association for the same time have been eleven hundred and forty-two dollars and eighty-seven cents ($1,142.87), which may be classified, in general, as follows: —

Cost of paper, printing, and binding the Buffalo volume of Proceedings, five hundred and thirty-four dollars and forty-eight cents,	$534.48
Charges connected with the Buffalo meeting, forty-five dollars,	45.00
Charges connected with the Burlington meeting, twenty-six dollars,	26.00
Salary of the Permanent Secretary, five hundred dollars,	500.00
Postage, express charges, and other expenses, thirty-seven dollars and thirty-nine cents,	37.39

The particular items may all be found in the cash account of the Secretary, which is herewith submitted as a part of his report. The balance in the hands of the Permanent Secretary August 21, 1867, is four hundred and twenty-two dollars and ninety cents ($422.90). There is no balance at present in the hands of the Treasurer.

JOSEPH LOVERING,
Permanent Secretary.

Burlington, August 21, 1867.

CASH ACCOUNT OF THE

Dr. AMERICAN ASSOCIATION *in*

Postage,	$10.00
Ripley's bill for printing circulars,	7.00
Sibley's bill for express charges,	2.00
Sawin's express,	1.25
Postage,	6.00
Salary of Permanent Secretary,	500.00
Journey to Burlington in May,	26.00
Harris's bill as clerk,	45.00
Thirty-four Reams of Paper,	221.76
Paper for cover to Proceedings,	6.63
Postage,	5.00
Fox's bill for printing,	75.07
Fox's bill for printing,	47.10
Assignee's bill for printing,	153.60
Abbott for binding Proceedings,	23.32
American Academy for freight,	5.00
Sawin's Express,	4.30
Blank book for records,	1.00
Postage,	1.94
Discount on drafts,	.90
	$1,142.87
Balance to next account,	422.90
	$1,565.77

PERMANENT SECRETARY. Cr.

Account with JOSEPH LOVERING.

Balance from last account, ...	$66.44
Assessments (from No. 184 to No. 420 of Cash Book) including the sale of Proceedings, ...	990.33
Received from the Treasurer, ...	509.00
	$1.565.77

REPORT OF THE AUDITORS.

THIS certifies that we have this day examined the above account of the Permanent Secretary, comparing the credits with the receipt-book and cash account, and the debits with the several vouchers; that we find the whole correct, and the sum of four hundred and twenty-two dollars and ninety cents ($422.90) credited to the next account.

(Signed) B. A. GOULD, C. S. LYMAN, } *Auditors.*

BURLINGTON, August 26, 1867.

STOCK ACCOUNT OF THE PERMANENT SECRETARY.

Volumes Distributed or Sold.

VOLUMES.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.
Distributed to Members,										1	3	1	6	19	208
Harvard College,														1	1
Yale College,														1	1
Boston American Academy,														1	1
Boston Nat. Hist. Society,														1	1
Boston Athenæum,														1	1
Conn. Acad. Sciences,															1
Smithsonian Institution,														1	1
Buffalo Nat. Hist. Society,															1
Buffalo Young Men's Library,															1
Buffalo Historical Society,															1
Foreign Societies,*	5	5	5	2	5	4	3	3	4	2	2	2	2	4	57
Sold,							1		1				1	2	13
Baltimore, Peabody Institute,	1	1	1	1	1	1	1	1	1	1	1		1	1	1
Total,	6	6	6	3	6	5	5	4	6	4	6	3	10	32	289
Balance, April, 1867,	54	105	240	227	426	288	520	841	943	880	821	938	1010	1161	
Received from Binders.															933
Balance, April, 1868,	48	99	234	224	420	283	515	837	937	876	815	935	1000	1139	644

* See pages 175 and 176.

List of European Institutions to which Copies of Volume XV. of the Proceedings of the American Association were distributed by the Permanent Secretary in 1867.

Stockholm, — Kongliga Svenska Vetenskaps Akademien.
Copenhagen, — Kongel. danske Vidensk. Selskab.
Moscow, — Société Impériale des Naturalistes.
St. Petersburg, — Académie Impériale des Sciences.
" " Kais. Russ. Mineralogische Gesellschaft.
" " Observatoire Physique Centrale de Russie.
Pulkowa, — Observatoire Imperiale.
Amsterdam, — Académie Royale des Sciences.
" Genootschap Natura Artis Magistra.
" Zoölogical Garden.
Haarlem, — Hollandsche Maatschappij der Wettenschappen.
Leyden, — Musée d'Histoire Naturelle.*
Altenburg, — Naturforschende Gesellschaft.
Berlin, — K. P. Akademie der Wissenschaften.
" Gesellschaft für Erdkunde.
Bonn, — Naturhist. Verein der Preussisch. Rheinlandes, &c.
Breslau, — K. L. C. Akademie der Naturforscher.
Dresden, — K. L. C. Deutsche Akademie der Naturforscher.
Franckfurt, — Senckenbergische Naturforschende Gesellschaft.
Freiburg, — Königlich-Sächsische Bergakademie.
Göttingen, — Königl. Gesellschaft der Wissenschaften.
Hamburg, — Naturwissenschaftlicher Verein.
Hannover, — Die Naturhistorische Gesellschaft.
Leipsic, — Königlich Sächsische Gesellschaft der Wissenschaften.
Munich, — K. B. Akademie der Wissenschaften.
Prag, — K. Böhm. Gesellschaft der Wissenschaften.
Stuttgart, — Verein für Vaterländische Naturkunde.†
Vienna, — K. Akademie der Wissenschaften.‡
" K. K. Geographischen Gesellschaft.
" Geologischen Reichsanstalt.

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* Also, Volume XIV.
† Also, Volumes I. to III. and V. to IX., inclusive.
‡ Also, Volume II.

Württemburg, — Der Verein für Vaterländische Naturkunde.*
Basel, — Naturforschende Gesellschaft.
Bern, — Allgemeine Schweizerische Gesellschaft.
" Naturforschende Gesellschaft.
Geneve, — Société de Physique et d'Histoire Naturelle.
Neuchatel, — Société des Sciences Naturelles.
Bruxelles, — Académie Royale des Sciences, &c.
Cherbourg, — Société Académique.†
Dijon, — Académie des Sciences, &c.
Liège, — Société Royale des Sciences.
Lille, — Société Nationale des Sciences, de l'Agriculture, et des Arts.
Paris, — Institut de France.
" Société Philomatique.
" Société Météorologique de France.
Turin, — Accademia Reale delle Scienzie.
Madrid, — Real Academia de Ciencias.‡
Cambridge, — Cambridge Philosophical Society.
Dublin, — Royal Irish Academy.
Edinburgh, — Royal Society.
London, — Board of Admiralty.
" East India Company.
" Museum of Practical Geology.
" Royal Society.
" Royal Astronomical Society.
" Royal Geographical Society.
Manchester, — Literary and Philosophical Society.§
Batavia, — Societé des Arts et des Sciences.‖

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* Also Volumes I., II., III., V., and IX.
† Also, Volume XIV.
‡ Also, Volumes I. to VI., inclusive.
§ Also, Volumes I. to XIII., inclusive, except II. and IV.
‖ Also, Volumes I. to XIV., inclusive.

INDEX.

A.

Acadian Provinces, Geological Discoveries in, 117.
Account of the Permanent Secretary, Cash, 172.
———, Stock, 174.
Acoustics, communications on, 25.
Address of F. A. P. Barnard, Ex-president, postponed, 16.
Address of J. S. Newberry, President, 1 and 165.
Address of T. E. Wales, 164.
Astronomy, Communications on, 17.
Auditor's Report of the, 173.
Aurora Borealis, Periodicity of, 82.

B.

Barnard F. A. P., Address of, postponed, 16.
Bradley, L., on Tellurium, 37.
Burlington Meeting, executive Proceedings of, 162.
———, officers of, vii.
———, Proceedings of, 17.

C.

Cash account of the Permanent Secretary, 172.
Chemical Diagrams and Symbols, 39.
——— Nomenclature, 50.
Chemistry, Communications in, read, but not published, 159.
Chicago Meeting, officers of, x.
———, Time of, 165.
Climate of the Glacial Epoch, 108.
Committee, local, x.
——— on Zoölogical Nomenclature, 169.
——— standing, x.
Committees, special, ix.
Communication of Vibrations, 17.
Communications, number of, 162.
——— titles of, 159.
Constitution of the Association, xiii.
———, Amendment to, proposed, xx.
Corals, Zoölogical Affinities of the Tabulate, 148.

D.

Dawson, J. W., Geological Discoveries in the Acadian Provinces, 117.

E.

Embryology of Libellula, 153.
Epsomites, on the origin of, 135.
Equation, Personal in Transit Observations 22.
European Institutions to which Proceedings are distributed, 175.
Executive Proceedings of the Burlington Meeting, 162.

F.

Fishes, on some fossil, 144.
Fossil Fishes from Ohio, 146.
Fossil Reptiles and Fishes, on some, 144.
Fossils of Vermont, 158.

G.

Geological Discoveries in the Acadian Provinces, 117.
——— Map of Maine, 123.
Geology and Mineralogy, 92.
——— of Vermont, 120.
Glacial Epoch, Climate of, 108.
——— depression of ocean during the, 92.
Glaciers, Ancient, of the White Mountains, 127.
Gould, B. A., Eulogy on D. A. Bache, 165 and 168.

H.

Hematite Beds of America, 114.
History of the Burlington Meeting, 162.
Hitchcock, C. H., on a Geological Map of Maine, 123.
——— on the Distortion of Pebbles, 124,
——— on the Geology of Vermont, 120.
——— on the Winooski marble of Colchester, Vt., 119.
Hospitalities extended to the Association, 166.
Hough, G. W., on Personal Equation, 22.
——— on Meteorological Registration, 89.
Hungerford, Edward, Experiments on Snow, 39.
———, Climate of the Glacial Epoch, 108.
——— on the Ripton Sea Beaches, 112.

I.

Insect Fauna of Mount Washington, 154.
Institutions, European, to which Proceedings are sent, 175.
Iron in masses, on the occurrence of, 97.

L.

Labrador, Insect Fauna of, 154.
Latitude, Determination of, 19.
Libellula, on the Embryology of, 153.
Lignilites, on the Origin of, 135.
List of Institutions to which Proceedings are sent, 175.
Local Committee, address in behalf of, 164.
———, of Burlington, viii.
——— of Chicago, x.
Lovering, Joseph, Lecture upon Sound, 165.
——— on the Optical Method of Studying sound, 25 and 165.
——— on the Periodicity of the Aurora Borealis, 82.
——— Permanent Secretary, cash account of, 172.
———Report of, 171.
———Stock account of, 174.
Lyman, B. S., Hematite Beds of America, 114.
Lyman, C. S., Observations of Venus, 23.
——— on Wave Apparatus, 33.

M.

Marble of Colchester, Vt., 119.
Marsh, O. C., on Lignilites or Epsomites, 135.
Mathematics and Physics, 17.
———titles of communications, read, but not published in, 159.
Meeting, Burlington, executive Proceedings of, 162.
——— officers of, vii.
——— Chicago, officers of, x. and 165.
———, time of, 165.
——— of the Association, former, xi. and xii.
Members of the Association, xxiii.
Meteorological Registration, 89.
Mount Washington, Geological structure of, 127.
———, Insect Fauna of, 154,
Musical Intervals, on a method of measuring, 27.

N.

Natural History, 92. .
———, titles of communications read, but not published in, 160.
Newberry, J. S., Address of, as President, 1 and 165.
——— on Fossil Reptiles and Fishes, 144.
——— on Fossil Fishes from Ohio, 146.
——— Reply to Mayor Wales, 164.

O.

Ocean, on the Depression of, 92.
Officers of the Burlington meeting, vii.
——— of the Chicago meeting, x.
Optical Method of studying Sound, 25.
——— Lecture and Experiments on the, 165.
Orthoptera of North America, 151.

P.

Packard, A. S., Embryology of Libellula, 153.
———, on Insect Fauna, 154.
Papers, number of, presented, 162.
——— titles of, read, but not published, 159.
Peabody, George, Thanks to, 168.
Pebbles, in Conglomerates, 124.
Peirce, Benjamin, on the Communication of Vibrations, 17.
Periodicity of the Aurora Borealis, 82.
Perry, J. P., Red Sandstone of Vermont, 128.
——— Note to the paper of, 158.
Physics, Communications on, 37.
——— of the Globe, 82.
——— and Mathematics, 17.
Physics, communications read, but not published in, 159.
Prime Vertical, Observations in, 19.
President Newberry, Address of, 1.
Proceedings, Executive, 162.
——— of the Burlington Meeting, 17.
Proceedings, to what Institutions distributed, 175.

R.

Red Sandstone of Vermont, 128.
Report of Auditors, 173.
——— of Committee on Weights and Measures, 167.
——— of Joseph Lovering, Permanent Secretary, 171.
Resolutions adopted, 167.
Ripton Sea Beaches, 112.
Rogers, W. A., on the Determination of Latitude, 19.
Rules of a permanent character, xxi.

S.

Sandstone of Vermont, on the Red, 128.
Sea Beaches, Ripton, 112.
Scudder, Samuel H., Orthoptera of North America, 151.
Secretary, Permanent, cash account of, 172.
——— report of, 171.
——— Stock account of, 174.
Sound, on the Optical Method of studying, 25.
———, Lecture, and Experiments upon, 165.
Snow, Experiments on, 39.
Stock, Permanent Secretary's account of, 174.

T.

Table of Contents, 177.
Tellurium, a Metal, 37.
Thanks, votes of, 170.
Tillman, Samuel, on a Method of Measuring Musical Intervals, 27.
———on Chemical Diagrams and Symbols, 39.
——— on a new Chemical Nomenclature, 50.
Titles of communications read, but not published, 159.
Transit Observations, Personal Equation in, 22.

V.

Venus, Observations of, 23.
Vibrations, Communication of, 17.
Volumes on hand, 174.
Vose, George L., Ancient Glaciers of the White Mountains, 127.
Votes of Thanks, 170.
Vermont, on the Fossils of, 158.
——— on the Geology of, 120.
———, on the Red Sandstone of, 128.
Verrill, A. E., on the Tabulate Corals, 148.

W.

Wales, T. E., Welcome by, 164.
Ware Apparatus, on a new form of, 33.
Weights and Measures, Report on, 167.
White Mountains, Geological Structure of, 127.
———, Glaciers in, 127.
Whittlesey, Charles, on the Depression of the ocean, 92.
———, on the occurrence of Iron, 97.

Z.

Zoölogical Affinities of the Tabulate Corals, 148.
——— Nomenclature, 169.
Zoölogy, communications in, 148.

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